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ZOOLOGY.

VOL. XXXII.

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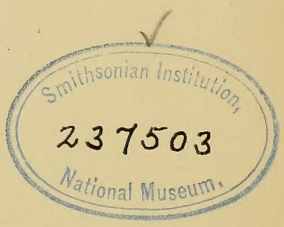
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ERRATA.

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53, line 26, for *Calliætis* read *Calliactis.*

69, line 2, for *Pleriplaneta* read *Periplaneta.*

128, line 7, for *Pellomyxa* read *Pelomyxa.*

157, line 20, for *tuberosa* read *tubulosa.*

179, line 3, for *T.* read *Callosune.*

273, line 4, read *N. romeri* (Neugeboren), Brady.

380, line 2, for *T. ligatum*, Müller, *read* T. ligata (*O. F. Müll.*).

380, line 4, for BALTEATUM, *Sowerby*, read BALTEATA, (*Sowerby*).

385, line 25, for *eximia* read *eximius.*

Plates 4-6, *for* HEXACTINÆ, *read* HEXACTINIÆ.

„ 26 & 27, *read* nov. gen. et sp.

„ 34, *for* X *read* ×.

„ 48 & 49, transpose the numbers; in the plate originally numbered 49 (now 48), add 7 to the top right-hand figure above fig. 15, and the ocelli now numbered 14 should be corrected to 4.

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(ZOOLOGY.)

The Spermatogenesis of *Stenobothrus viridulus*; with Special Reference to the Heterotropic Chromosome as a Sex Determinant in Grasshoppers.

By Capt. C. F. U. Meek, F.L.S.

(Plates 1–3.)

[Read 1st December, 1910.]

Introduction.

Since Van Beneden discovered in 1883 that the somatic number of chromosomes is halved in the mature germ-cells of both sexes, the attention of investigators has been turned to the phenomena of the maturation divisions and to the problems to which they give rise. The literature upon spermatogenesis and oogenesis has become very extensive, and it is impossible to discuss here the numerous questions that have arisen during the last few years. I shall therefore touch only upon certain points of controversy, directly concerned with the morphology and function of the chromosomes.

Although the halving of the somatic number of chromosomes is no longer denied, considerable disagreement exists as to the manner in which reduction is effected. In the eumitotic type of maturation, both mitoses are regarded as being equational; but the majority of cytologists uphold the doctrine of pseudomitosis, in which one maturation division is reductional. They have, however, not decided whether this division is the first or second; and in this way the rival theories of Pre-reduction and Post-reduction have arisen.

The researches of vom Rath in 1892–5 upon the spermatogenesis of

Gryllotalpa led him to assert that the first maturation division is longitudinal, the second being transverse and reductional ; and McClung's paper upon *Hippiscus* in 1899 has corroborated this view. Further evidence in support of the theory of Post-reduction has since been supplied by the work of Sutton upon *Brachystola magna,* and by the more recent investigations of Nadine Nowlin and Robertson upon *Melanoplus bivittatus* and *Syrbula admirabilis* respectively. On the other hand, de Sinety, in a paper upon the Phasmidæ, has declared that both maturation divisions in the Orthoptera are longitudinal and equational. In 1905 Montgomery, writing on *Syrbula,* and Farmer and Moore, writing on *Periplaneta,* upheld the theory of Pre-reduction ; and this view has since been adopted by Davis in a paper upon the Acrididæ and Locustidæ, and by Gerard in a paper upon *Stenobothrus biguttulus.*

The studies of Sutton upon *Brachystola magna* led to certain discoveries with regard to the chromosomes themselves: firstly, he found that they exhibited a remarkable degree of isolation, for each became enclosed in a distinct vesicle during the telophase of the secondary spermatogonial mitosis. These vesicles fused later at one polar extremity, with one exception to which I shall allude. Since the chromosomes remain in compartments during resolution into spiremes, he has concluded that their individuality is never lost, and that they are morphologically independent units : this phenomenon has been observed by Otte in *Locusta viridissima,* but is apparently confined to a small number of organisms. The nucleus at this stage usually exhibits a long, continuous, and highly convoluted spireme, or even a complete reticulum, formed by the combined resolution of the chromatin filaments ; Gerard describes this condition in *Stenobothrus biguttulus,* in which he finds no trace of separate vesicles.

Sutton further discovered in *Brachystola* that the chromosomes of the spermatogonial complex invariably show certain size and shape relationships, and that, with one exception, they can be arranged in a graduated series of pairs : this has since been corroborated in other types by the work of Baumgartner, Davis, Gerard, McClung, Montgomery, Nowlin, Robertson, the Schreiners, Stevens, and Wilson. He found moreover that these relationships persist in the later spermatocytes, and, since the number of chromatin bodies is halved at this stage, concluded that a conjugation of members of the spermatogonial pairs had occurred during the intervening period. This view is now held by the majority of cytologists ; and Otte says that he has actually witnessed a side to side conjugation of chromosomes in *Locusta.* Bonnevie, Sainmont, Wilson, and von Winiwarter carry the theory even further, for they believe that there is complete fusion of the associated chromosomes during this period of lateral juxtaposition ; on the other hand, the entire theory of conjugation is denied by Duesberg, Fick, Gerard, and Meves.

This theory has been eagerly seized by Mendelians to explain the

segregation of character factors necessary to that mode of inheritance: the members of each spermatogonial pair are assumed to be respectively paternal and maternal in derivation, so that the juxtaposition of their component chromomeres permits the exchange of character factors obtained from the two parents. This is merely an hypothesis, but there seems to be little doubt that the number and size and shape relationships of the chromosomes are constant for the species; and it is probable that we shall eventually find morphological correlation between the complexes of allied members of a group.

Lastly, there is the problem of the heterochromosomes, investigated originally by Wilson, and divided by him into three classes—idiochromosomes, heterotropic chromosomes, and microchromosomes. The first-named consist of two elements, differing in size and staining deeply during the resting stages and growth period of the primary spermatocytes; they later conjugate, and still later divide, the larger passing to one pole and the smaller to the other. The oogonia show a corresponding pair of chromosomes, but in this case both are of the same size. Spermatozoa possessing the larger idiochromosome produce females, those possessing the smaller produce males. The heterotropic chromosome occurs in the spermatogonial cell as a single element, and behaves like the ordinary chromosomes in the second maturation mitosis, but passes entire to one daughter cell at the first. As in the case of the idiochromosome, it is represented in the oogonia by a pair. Spermatozoa containing the heterotropic chromosome produce females, and those without it males. Wilson has suggested that, in the male, it acts as a male determinant, and that it passes from one sex to the other alternatively, being recessive in the female: Hertwig, Paulmier, and Wassilieff regard it as a degenerating chromosome that will eventually become extinct—a view strongly opposed by McClung.

In 1899 McClung drew attention for the first time to this peculiar chromosome in the male germ-cells of *Xiphidium*; and it has since been studied in a large number of organisms, particularly Orthoptera. He found that it undergoes no resolution into a spireme during the primary spermatocyte resting-stage, but persists as a compact and darkly staining body on the periphery of the nucleus: he erroneously stated that it divides longitudinally at both maturation divisions, but corrected this mistake in a later paper upon the Locustidæ. This "accessory" chromosome of McClung has been found by de Sinety in the Phasmidæ, and by Sutton in *Brachystola*: Baumgartner has studied it in *Gryllus*; and his results have been confirmed by Gutherz, working upon the same material. Otte has observed it in *Locusta*, Gerard in *Stenobothrus biguttulus*, Nowlin in *Melanoplus bivittatus*, and Robertson in *Syrbula admirabilis*: Davis has seen it in every member of the Acrididæ and Locustidæ that he has studied, and further, has shown that this "monosome" is represented in the oogonia by a pair of

chromosomes. He found it in certain cases enclosed in a vesicle during the resting-stage, but considers this condition artificial and unimportant.

Somewhat different results were obtained in 1905 by Montgomery working upon *Syrbula acuticornis*, for he declared that the heterotropic chromosome is represented in the spermatogonial cell by two chromosomes, and that it divides at both maturation divisions. Robertson's researches however upon the closely allied *S. admirabilis* afford no evidence of this paired condition, and support the view that this chromosome passes entire to one pole at the first maturation division, splitting longitudinally at the second : this seems to be the normal occurrence in the Orthoptera, for it has been observed by Baumgartner, Davis, Gerard, Gutherz, McClung, Nowlin, Otte, Robertson, de Sinety, Sutton, Wilson, and others.

The discovery in the male germ-cell of an odd chromosome, which passes entire to one pole at a subsequent mitosis, and the discovery that in allied types the unequal members of one spermatogonial pair pass to opposite poles have proved that dimorphism of spermatozoa exists in certain groups : and, since spermatozoa of the one kind produce males, and those of the other females, sex, in these organisms, must be determined at the moment when the spermatozoon enters the micropile, immediately prior to amphimixis. This has given rise to the hypothesis that dimorphism of spermatozoa occurs throughout the animal kingdom, and that sex is determined in this manner.

It is possible that the presence or absence of a particular chromosome is the factor controlling sex ; but it is equally possible that this chromosome contains only certain of the numerous characters peculiar to one sex, and that its passage to one pole is closely connected with the passage to that pole of the ordinary chromosomes, after they have divided on the equatorial plate. The function of the chromosomes is not yet understood : although the majority of cytologists believe that the chromatin alone contains the bearers of the hereditary characters, some still affirm that the cytoplasm is the sole agent in this respect, and that the chromatin fulfils the subordinate rôle of a nutritive substance. The experiments of Boveri upon the fertilization of enucleated Echinoderm ova appeared convincing, but unhappily the same experiments repeated by Delage and others gave diametrically opposite results. It seems of little importance whether the transmitted material is composed of actual character factors, or whether it represents a concatenation of physical units, resulting in the phenomena implied in heredity ; but it is important to ascertain by what means these phenomena are reproduced generation after generation.

The character factors may eventually be found to reside in both chromatin and cytoplasm, being distributed in the latter during the resting-stages for purposes of nutrition, and being collected together in the chromatin filaments only during the stages immediately preparatory to karyokinesis: this would

explain the resolution of the chromosomes into spiremes or reticulum, and their later shortening and consequent closer association of granules—the chromatin in this case serving merely as a convenient vehicle for the precise distribution of character factors, or their equivalents, between the two daughter cells.

Material and Methods.

My material was collected at Nannerch, in Flintshire, N. Wales, in the last week of August 1909. The grasshoppers were killed in chloroform within a few hours of capture, and were placed whole in the fixative after the wings and legs had been removed, and the integument of the back slit up to allow readier access to the fluid. I have obtained excellent results with Perenyi's chromo-nitric acid solution, the resting-stages and various phases of mitosis being very perfectly preserved : the majority of writers on insect spermatogenesis, however, appear to have used Flemming's strong chromo-aceto-osmic acid solution, Hermann's platino-aceto-osmic acid solution, or the fixatives of Bouin and Zenker.

The grasshoppers were transferred after two hours to a 50 % aqueous solution of alcohol, and an hour later were placed in a 70 % solution, in which they remained for twelve hours ; they were then stored in a solution of 80 % alcohol. This storage solution was changed twice during the first month, having become thick and discoloured with pigment.

When required for embedding, the testes were dissected out, and placed for twenty-four hours in a 90 % solution of alcohol : after being passed through absolute alcohol and cleared in cedar-wood oil, they were embedded in paraffin, remaining for twenty minutes in the first bath and for fifteen in the second. I used paraffin with a melting-point of 52° C., since I found that paraffin with a higher melting-point had a tendency to overheat the cells. Sections were cut with an ordinary Cambridge rocking microtome to thicknesses varying from 5 to 10 μ, and were invariably stained on the slide. The nuclear stains used were Heidenhain's iron hæmatoxylin, iron brazilin, and safranin, the first-named being used alone or in conjunction with a plasma stain—*e. g.*, eosin, congo-red, or picro-carmine ; I also used the tricolor stain of Flemming, and the permanganate of potassium method of Henneguy.

In staining with the iron hæmatoxylin, I used, as a mordant, an aqueous solution of iron alum, in which the slides remained for six hours ; they were then stained for twelve or fifteen. Davis left his slides in the mordant for only two hours, and in the stain for from four to six ; but I have found that the longer period gives better results as regards sharp definition, while the process of differentiation can be more perfectly controlled. In the cases where a second stain was used, the slides were left for ten minutes in the plasma stain before being transferred to the iron hæmatoxylin : the iron

alum has no effect upon the former, but this cannot be said of the alcohol; so great care must be taken not to wash out the whole of the plasma stain in the subsequent process of dehydration through successive strengths of alcohol. The iron hæmatoxylin gives the best results in all cases where it is required to bring the chromosomes and nucleoli into evidence; and this is particularly noticeable when camera-lucida drawings are needed. Davis obtained his best results with iron hæmatoxylin in conjunction with bordeaux-red, and has confined himself almost entirely to this combination.

When staining with safranin I used a 50 % solution in alcohol, leaving the slides in it for from twelve to twenty-four hours; this gives an orange-grey tint to the protoplasm, the chromatin staining bright red. Henneguy's method is a modification of this, for the safranin used is made by Zwaardemaker's formula, being a mixture of equal volumes of alcoholic safranin and anilin water: the slides were placed for five minutes in a 5 % aqueous solution of permanganate of potassium, which acts as a mordant, and then stained for six or twelve hours, after careful washing in running water. The excess of colour was removed by a high strength of alcohol. Wilcox used this method when working upon *Caloptenus femur-rubrum*, and obtained good results; he however allowed the slides to remain in the stain only for a few minutes.

In the iron brazilin method, first described by Hickson *, no second stain is necessary, for the cytoplasm as well as the chromatin is affected: the slides were placed for two or three hours in a solution of iron alum in 70 % alcohol, and were then stained for from sixteen to twenty-four hours. This stain is useful for studying late stages of unripe spermatozoa and their earlier spermatid transformations.

The tricolor stain of Flemming gives very delicate results, particularly in stages other than those of actual mitosis. I stained in safranin for forty-eight hours, and washed the superfluous colour out with strong alcohol; the slides were then taken down to water through successive strengths of alcohol, and were stained for several hours in an aqueous solution of gentian, after which they were washed in water and placed for ten minutes in a similar solution of orange G, which acts as a differentiating agent for the gentian. This combination gives a purple tint to the chromosomes and nucleoli, the spindle fibres, &c., appearing in various shades of grey and brown.

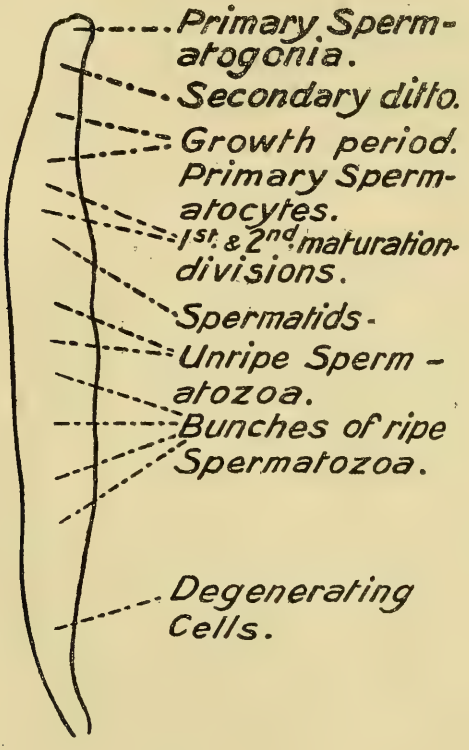
The Follicles of the Testis.

The testes are two ovoid paired organs lying dorsally to the alimentary canal in the middle of the abdomen, and so closely associated that they can

* Hickson, S. J., "Staining with Brazilin," Quart. Journ. Micr. Sci. xliv. p. 469, 1901.

be dissected out as a single body: they consist of a number of tubular follicles, tapering at the ends, and opening posteriorly into a duct communicating with the vas deferens.

By numbering the follicles in a section, and allotting the same numbers to corresponding follicles in successive sections of a complete series, it is possible to reconstruct the follicle in any particular case, and to recognize the true position of one section in the whole, in cases where the razor has cut transversely or at an angle to the plane of length.



At the anterior end of each follicle is a single cluster of primary spermatogonia with the apical cell, and several clusters of secondary spermatogonia, arranged without definite order. The resting- or growth-stages of the primary spermatocytes occupy a considerable area, lying posteriorly to the spermatogonia; and the heterotropic chromosome is here seen for the first time as a dark and compact body apposed to the nuclear membrane.

We next see the various phases of the primary and secondary spermatocyte mitoses, there being no resting-stage between these two divisions. Proceeding still further towards the posterior end of the follicle, we meet with the transformation from spermatids to unripe spermatozoa; the former are

in scattered groups, and the latter in more closely associated bunches. Beyond these are dense masses of ripe spermatozoa, placed at considerable intervals in the lumen of the follicle: the extreme end is occupied by degenerating cells that will undergo no further development.

The posterior half of the follicle is occupied by unripe and ripe spermatozoa, and the greater part of the anterior half is closely packed with the primary spermatocyte growth-stages. The follicle is divided into tracts, in which these various stages are found, the partitions arising from the follicle wall: further subdivision is effected by septa, dividing the tracts into cysts. Cells in one cyst are not all at the same stage; and the precocious cells of one section correspond with the laggards in the next. When the follicle has been cut at right angles to its length, the succession of stages can be followed with great accuracy until we come to the spermatids, when the identity of the follicle is lost, clusters of spermatozoa alone being distinguishable.

Spermatogonia.

The extreme anterior zone of the mature follicles is divisible into two parts, occupied respectively by the primary and secondary spermatogonia. The former are arranged in a single layer round a central cell—the apical cell—recognizable by its regularly ovoid nucleus, in which lies a group of large and deeply staining granules, the ordinary chromatin particles being distributed in irregular blotches. The nuclei of the primary spermatogonia are situate in the region of their cytoplasm furthest from the apical cell, and present a lobulate appearance, as can be seen in fig. 1, on Plate 1. The chromatin is disposed in minute particles upon the linin threads of an apparently complete reticulum; and I have failed to find any massing of larger granules, as in the case of the apical cell. Each follicle contains one apical cell with its attendant primary spermatogonia.

At present little is known of the nature of this apical cell, which has been found and studied in many insect forms, but principally in the Lepidoptera; its function is not yet understood, but it probably plays an important rôle by affording either nourishment or physical support to the cells destined to become spermatozoa. On the other hand, it has been suggested that it is a degenerate spermatogonial cell, or the mother cell of the primary spermatogonia surrounding it, or that its function is connected with the formation of the zones into which the follicle portions are subdivided. Davis has found it in the members of the Acrididæ and Locustidæ that he has studied, and has shown that in *Dissosteira carolina*, *Arphia tenebrosa*, *Chortophaga viridifasciata*, and *Stenobothrus curtipennis* it is completely surrounded by the single layer of primary spermatogonial cells, but only partly surrounded in *Melanoplus femoratus* and *Hippiscus tuberculatus*, being at one side in

contact with the connective-tissue cells. Gerard further distinguished it in *Stenobothrus biguttulus* by its deeper cytoplasmic colouring ; but I have not found this in my material. The cluster of primary spermatogonia is surrounded by numerous connective-tissue cells, recognizable by their small size and deeply stained nuclei. The secondary spermatogonial groups are completely enclosed by cyst-walls, formed from connective-tissue cells, and lie posteriorly to the primary spermatogonia in irregularly disposed clusters, often so closely packed that the cells become distorted. Each group has been formed by repeated division of a single cell, originally extruded from the primary spermatogonial figure, so that there is a continuous stream of cells passing towards the posterior end of the follicle. A secondary spermatogonial cyst is shown on Plate 1. fig. 2, from which it will be seen that these cells closely resemble the primary spermatogonia, but are easily distinguishable by the absence of the apical cell.

As in the case of the primary spermatogonia, the resting-stage nucleus shows a series of chromatin granules disposed along linin threads : I have been unable to discover whether we are dealing here with one continuous thread, much convoluted, or with a number of threads, irregularly placed in such a manner that they combine to give this reticular appearance. Montgomery seems to have experienced the same doubt in the case of *Syrbula*. Davis merely describes a network, in which chromatin granules are massed at the intersections of the linin threads.

There are two spermatogonial generations ; and this agrees with the results of Montgomery upon *Syrbula acuticornis*, Gerard upon *Stenobothrus biguttulus*, and Davis upon numerous members of the Acrididæ and Locustidæ. Sutton however has declared that there are eight in *Brachystola* ; and Wilcox has been unable to determine the exact number in *Caloptenus femur-rubrum*. McClung suggests that the number varies with the species.

In the resting-stages the nucleus is not deeply stained. The prophase of division is characterized by the flowing together of granules on the linin threads ; and these chromatin particles become more and more closely associated until they form the ragged filaments, representing the forerunners of the compact bodies that later appear on the periphery of the karyokinetic spindle. As condensation proceeds, the chromatin exhibits greater affinity for the iron hæmatoxylin, so that distinct correlation exists between the intensity of staining and the degree of proximity of the associating particles. The formation of the spindle is preceded by the appearance of two small asters in the cytoplasm, close to the periphery of the nucleus. The chromatin filaments have by this time assumed the shapes and sizes characteristic of the chromosomes ; and they now arrange themselves on the equatorial plate, preparatory to division, the metaphase complex showing seventeen chromosomes of varying shapes and sizes.

In every complex that I have studied I have found the same number of chromosomes, and the same size and shape relationships. With the exception of the heterotropic chromosome, the members of the complex can be arranged in a graduated series of eight pairs, divisible into three groups, small, large, and medium: there are three small pairs, of which two are spherical and the third ovoid, three pairs of large rod-shaped chromosomes bent slightly at the middle, and two pairs of medium chromosomes, which usually appear as straight rods. The heterotropic chromosome is the fourth largest in the complex, and is a straight or very slightly bent rod, recognizable for the first time at this stage. By choosing metaphases where the chromosomes overlap only to a small extent, and by making camera-lucida drawings upon successive occasions and comparing results later, I have tried to minimize the possibility of error in counting the number of chromosomes present; this difficulty is not experienced in the metaphases of the spermatocytes, where only half the spermatogonial number is found, and where cells can be chosen in which no overlapping occurs. Plate 1. figs. 3 & 4 show polar views of the spermatogonial metaphase, the seventeen chromosomes being arranged on the equatorial plate.

Gerard has found seventeen chromosomes in the spermatogonial complex of *Stenobothrus biguttulus*, and Davis's results in the case of *S. curtipennis* agree with this. McClung in an early paper suggested that the number is dependent on the family, and is a constant, but this has not been found to be strictly true. I believe the number is constant for the genus, but not for a larger subdivision of the animal kingdom. Since the number has been found to vary in the Orthoptera, it is interesting to compare the results of writers upon this subject. Sutton has found twenty-three chromosomes in *Brachystola magna*, capable of being arranged in three small and eight large pairs, with an odd or heterotropic chromosome ranking among the latter. Davis has counted the same number in *Arphia tenebrosa, Hippiscus tuberculatus*, *Chortophaga viridifasciata*, and *Melanoplus femoratus*. In the Locustid, *Steiroxys trilineata*, he has found twenty-nine, and has shown that in all cases the ordinary chromosomes can be arranged in pairs forming a graduated series. McClung has observed thirty-three chromosomes in *Xiphidium fasciatum*; and Nadine Nowlin has counted twenty-three in *Melanoplus bivittatus*. When working upon crickets, Baumgartner found twenty-nine in *Gryllus assimilis* and twenty-one in *G. domesticus*.

The chromosomes, after placing themselves on the spindle, divide longitudinally, and their halves pass to opposite poles; the division of the heterotropic chromosome is longitudinal, but occurs often at a later stage, when the ordinary chromosomes have begun to move apart: an example of the secondary spermatogonial telophase in shown on Plate 1. fig. 5. On reaching the poles the chromosomes elongate and appear to lose their affinity for the iron hæmatoxylin: as the nuclear membrane reforms, they

become more and more ragged ; and this dissociation of chromatin continues until we see again the characteristic resting-stage with its chromatin granules disposed along linin threads, which combine either in reality or in appearance to produce a complete reticulum. The whole process is merely an inverse repetition of that preceding division. The heterotropic chromosome takes no part in this diffusion of chromatin, and remains throughout this stage as a darkly stained and homogeneous body apposed to the nuclear membrane, where its affinity for the stain and smooth outline render it extremely conspicuous.

Primary Spermatocytes.

After the last spermatogonial division, resulting in the formation of two daughter primary spermatocytes, the nucleus is much reduced in size. McClung has pointed out that at this stage reproduction is replaced by constructive metabolism, and that the chromosomes, after exhausting their metabolic resources, unite their common energies to build up a new cytoplasm. This suggestion probably furnishes the true explanation, but in any case possesses considerable pragmatic value, for some process of this nature undoubtedly occurs.

The cells undergoing this resting- or growth-stage occupy large areas in the follicle, and the gradual increase in size as we proceed more and more posteriorly is very noticeable. This growth-period is continued until the nucleus has attained its maximum size, when the cell enters the prophase of the next mitosis. Plate **1.** figs. 6 & 7 show the difference between the primary spermatocyte immediately after the secondary spermatogonial division and immediately before the next mitosis. The nucleus shows a reticulum, composed of chromatin granules placed along linin threads, the individuality of the ordinary chromosomes being completely lost.

It will be remembered that at this stage Sutton found no loss of individuality of the chromosomes in *Brachystola* ; each chromosome underwent resolution into a spireme in a separate sac, in which it remained completely isolated, although the sacs fused at one end to form a common chamber. He consequently met with no reticulum, or appearance of a reticulum, and so put forward this phenomenon as a convincing proof of the individuality of the chromosomes. Robertson observed a similar condition in *Syrbula*, but did not always find the sacs, containing the ordinary chromosomes, clearly distinguishable. Both Sutton and Robertson describe a distinct vesicle, in which the heterotropic chromosome lies, having no morphological connection with the vesicles of the other chromosomes. I have been unable to find the smallest trace of such vesicles, and am confirmed in this by the work of Gerard on *Stenobothrus biguttulus*—a member of the same genus.

The prophase of division is characterized by the closer association of chromatin granules on the linin threads of the reticulum; and this process continues until the latter is resolved into a number of ragged filaments, which shorten and thicken, and later assume a boomerang shape. By this time all trace of the component granules is lost; and the ragged horseshoe bodies, folding themselves into figures of eight and rings, are gradually transformed into the smooth and clearly defined chromosomes. The resolution of the reticulum into filaments is shown on Plate **1.** fig. 8, and the subsequent shortening and thickening of the boomerangs in fig. 9 of the same Plate. The various shapes assumed by the chromatin filaments at a still later stage are shown on Plate **2.** figs. 10–19, the most prominent types being crosses, rings, and loops. The last-named may be doubled to form a complete figure of eight, or may form a single loop with free ends twisted or crossed over one another.

As soon as the centrosomes have taken up their position at the poles, the chromosomes appear on the equatorial plate, and the characteristic metaphase figure is once more represented. The heterotropic chromosome remains as a dark and smoothly outlined body close to the nuclear wall while the chromatin filaments are being transformed into chromosomes: it then takes its place among them on the mitotic spindle. The number of filaments evolved from the reticulum is eight, so that nine chromatin bodies compose the metaphase complex. In this manner the sixteen ordinary chromosomes of the spermatogonial cell have been halved, and this reduction must be effected before the breaking up of the spireme, for I have found no evidence of lateral association of filaments after this has occurred. Gerard has obtained similar results, but explains the reduction of the somatic number by describing an association of granules, the reticulum meshes combining in pairs by means of fine anastomosing threads; he has found that this process always begins near the heterotropic chromosome. On the other hand, Davis denies that a continuous spireme is formed, but mentions a similar massing of granules at this stage; he describes how the spiremes appear later in the form of loops, attached by their free ends to the nuclear membrane, and, since the number of loops is half the somatic number of the chromosomes, suggests that each loop is composed of two univalent chromosomes united end to end.

The chromosomes on the equatorial plate exhibit the same size and shape relationships found in the spermatogonial complex: of the eight ordinary chromosomes, three are large, three small, and two of medium size, the heterotropic chromosome again being the fourth largest. This can be seen from Plate **2**, where a polar view of the metaphase is given in fig. 20. The smaller chromosomes are the first to divide, division in all cases being longitudinal; this agrees with the results of Baumgartner, Gerard, Henderson, McClung, Montgomery, Nowlin, Robertson, Sutton, Wilcox,

and others. The heterotropic chromosome does not divide at this mitosis, and may often be seen on its way to one pole, while the ordinary chromosomes are still on the equatorial plate. Illustrations of this are shown on Plate 2. figs. 21 & 22, and a still later stage in fig. 23, where the ordinary chromosomes, still attached to one another by connecting-fibrils, are moving towards the opposite poles. In every case the heterotropic chromosome passes entire to one daughter cell, so that dimorphism of the spermatozoa is effected at this mitosis, half the resulting secondary spermatocytes possessing this odd chromosome, and half being without it. No resting-stage follows the telophase, for the two maturation divisions occur in rapid succession.

Secondary Spermatocytes.

Large areas are frequently to be seen occupied by cells undergoing these two divisions; and the absence of an intervening resting-stage is not characteristic only of this species, for it has been observed in many other types.

The chromosomes that assemble on the mitotic spindle are nine or eight in number, the difference depending upon the presence or absence of the heterotropic chromosome, which is found in only half the cells. The complex exhibits the same size relationship that occurred in the earlier metaphases: there are once more three small chromosomes, of which two are spherical and the third ovoid, three large chromosomes appearing as V's with their component arms closely folded on one another, and two chromosomes of intermediate size, also represented by a pair of arms joined at one extremity. The heterotropic chromosome, when present, is still the fourth largest of the complex. Examples of polar views of the metaphase, showing the chromosome complex, are given on Plate 2. figs. 25, 26, & 27.

Later we see the ordinary chromosomes dividing in mitosis at the junction of their component arms, one arm going to each pole. If the arms are really the associated members of the spermatogonial pairs, this division must effect the separation of chromosomes that became laterally associated two generations previously; and if we accept the further hypothesis that the members of these pairs are respectively paternal and maternal in derivation, we must regard this mitosis as the means of separating chromosomes obtained from the two parents, after a possible exchange of chromatin. There is however no direct evidence to prove that the component arms of these V-shaped chromosomes correspond with the members of the spermatogonial pairs, or that the members of the pairs are derived from both parents, although there are reasons for assuming the truth of these two suppositions.

The heterotropic chromosome is the last to divide, and can often be seen on the periphery of the mitotic spindle when the ordinary chromosomes are

massing at the poles ; on these occasions it appears in the form of two V's, whose apices are distally placed with respect to one another. An illustration of this phenomenon is given on Plate **3.** fig. 28. This "lagging" of the heterotropic chromosome has been observed by Baumgartner in *Gryllus*, by Davis in numerous members of the Acrididæ and Locustidæ, and by many writers in the case of other types.

The cytoplasm becomes constricted shortly after the chromosomes have passed to the two poles, and in this manner two daughter spermatids are formed.

Spermatids.

As soon as the nuclear membrane of the spermatids has formed, the chromosomes become ragged, and dissociation of their component granules begins to take place. This process continues until the individuality of the ordinary chromosomes is completely lost, the nucleus exhibiting several irregularly placed blotches, in which the chromatin granules are faintly distinguishable. The heterotropic chromosome retains its individuality for a considerable time, remaining intact as a darkly stained body in the midst of the dissociating ordinary chromosomes ; it subsequently becomes resolved into a mass of granules, and loses its identity in the general chromatin reticulum. Plate **3.** fig. 29 shows a cell at this stage of development.

Shortly after this a body appears outside and in contact with the nuclear membrane, forming a conspicuous object on account of its great affinity for the iron hæmatoxylin and its characteristic bead or knob shape. The axial filament grows out from a clearly marked constriction in the middle of this "centrosome," and, as the cytoplasm of this region gradually elongates to form the tailpiece of the unripe spermatozoon, increases in length and appears as an indistinct line down its entire length. The chromatin granules have now become extremely minute, and the nucleus has the appearance of an uniformly grey body, in which the component chromatin particles cannot be distinguished. This gradual transformation is shown on Plate **3.** figs. 30 & 31.

The elongation of the tail and axial filament is later accompanied by a corresponding elongation of the nucleus, which loses its spherical shape and appears in that of a torpedo. The "centrosome" still occupies its original position between the axial filament and the posterior end of the nucleus, but is slightly reduced in size ; this can be clearly seen in figs. 32 & 33. The lengthening of the nucleus and tailpiece continues, and the "centrosome" becomes smaller and smaller. The nucleus gradually becomes darker, doubtless owing to a closer association of its chromatin particles. Plate **3.** figs. 34 & 35 show this further elongation, the reduced size of the "centrosome" being very noticeable.

The torpedo-shaped spermatids are to be seen scattered in the follicle, and are very prominent objects on account of the strong staining of the iron hæmatoxylin : they are placed usually with their heads towards the anterior end of the follicle, and travel as unripe spermatozoa, tail first, towards the posterior end. As they elongate further into the thin thread-like form characteristic of the unripe spermatozoa, they become associated in ragged clusters, which continue to condense until we find solid masses of ripe and finely drawn out spermatozoa situate at irregular intervals in the lumen of the follicle. Plate 3. fig. 36 shows the penultimate stage immediately preceding the transformation into the mature spermatozoon, and is a good example of the much reduced "centrosome" and the darkly staining and considerably elongated nucleus.

Summary.

1. The apical cell is found at the extreme anterior end of the mature follicle, completely surrounded by a single layer of primary spermatogonial cells. There is only one apical cell in each follicle.

2. The secondary spermatogonia occur in clusters and morphologically appear similar to the primary cells, but are recognizable by the absence of the apical cell and by the number of clusters.

3. The nucleus exhibits an apparently complete reticulum in the resting-stages of both primary and secondary spermatogonia : there is no trace of the identity of either heterotropic or ordinary chromosomes.

4. The chromosomes of the spermatogonial complex can be arranged in a graduated series of pairs, and are divisible into three groups, viz., large, small, and medium-sized chromosomes. The number of chromosomes is constant and is seventeen, the fourth largest being unpaired and corresponding with the "monosome" and "accessory" chromosome of other writers.

5. All the members of the spermatogonial complex divide in mitosis ; but the odd or heterotropic chromosome often "lags," and can be seen on the spindle when the ordinary chromosomes are assembling at the poles.

6. The nucleus is at its smallest size after the last spermatogonial division, and this stage is followed by a clearly observable growth-period, extending to the prophase of the first maturation division. In this resting-stage the nucleus again exhibits a chromatin reticulum, the granules being disposed along linin threads : the identity of the ordinary chromosomes is lost, but the heterotropic chromosome remains as a dark and homogeneous body close to the periphery of the nucleus, and undergoes no resolution into a spireme.

7. I have found no trace of separate sacs or vesicles in which chromosomes undergo transformation into spiremes, either in the case of the heterotropic or the ordinary chromosomes.

8. The equatorial plate of the primary spermatocyte mitosis shows nine

chromosomes, again divisible into three groups as regards size. The fourth largest of the complex is undoubtedly the heterotropic chromosome. The distinct correspondence between the size and shape relationships of the secondary spermatogonial and primary spermatocyte complexes points to the possibility of a lateral conjugation of members of the spermatogonial pairs during the intervening period, but is not a proof of it.

9. The ordinary chromosomes divide in the primary spermatocyte metaphase, and their halves pass to opposite poles of the spindle : the heterotropic chromosome shows no sign of division, and passes entire to one daughter cell, while the ordinary chromosomes are still on the equatorial plate. In this manner dimorphism of the subsequent spermatozoa is effected.

10. I have been unable to discover whether reduction—the separation of conjugant members—occurs at the first maturation division or at the next ; possibly both divisions are equational, and only a numerical reduction takes place as a result of lateral association of chromatin granules or masses on the reticulum threads prior to the primary spermatocyte prophase of mitosis.

11. There is no resting-stage between the first and second maturation divisions ; the constriction of the cytoplasm to form the two daughter secondary spermatocytes is closely followed by the appearance of the next karyokinetic spindle.

12. The complex of the secondary spermatocyte cell shows nine or eight chromosomes, and this difference is due to the presence or absence of the heterotropic chromosome, which is found in only 50 % of the cells. The chromosomes exhibit the same size relationships that occurred in the previous metaphases, there being three large chromosomes, three small, and two of intermediate size. The heterotropic chromosome, when present, is the fourth largest of the complex. Two of the three small chromosomes are spherical, and the third is ovoid or slightly dumb-bell shaped : the remainder appear as two arms jointed at one end and closely apposed to one another.

13. I find no direct evidence to prove that these arms are the representatives of the spermatogonial pairs.

14. Division occurs at the junction of the component arms. The heterotropic chromosome usually "lags," and can be seen on the spindle when the ordinary chromosomes have passed to the two opposite poles.

15. The formation of the nuclear membrane in the spermatids is followed by resolution of the ordinary chromosomes into their component granules. This process continues until the nucleus appears of an uniformly grey colour, in which the individuality of the chromatin particles is lost. The heterotropic chromosome remains at first as a darkly staining and irregular body, but later undergoes resolution into particles, whose identity is indistinguishable in the common chromatin mass.

16. The appearance of the "centrosome" is followed by the formation of

the axial filament, arising near the constriction in the middle of this body. The cytoplasm in this region elongates to form the tail of the unripe spermatozoon, and the axial filament appears as a faint line running down the centre of the tail. The elongation of the nucleus and the tailpiece continues, and is accompanied by a reduction of the "centrosome," which finally becomes extremely small.

17. The head of the spermatozoon is composed of the nucleus; the "centrosome" forms the middle piece, and the axial filament and its surrounding cytoplasm form the tail.

18. The spermatids travel later towards the posterior end of the follicle with their heads turned towards the anterior end; and this phenomenon is observable in the spermatozoa. The spermatids are found scattered in the follicle, the unripe spermatozoa in more closely associated clusters, and the ripe spermatozoa in solid bunches.

19. At no stage have I observed a discharge of chromatin from the nucleus, and I have seen nothing to suggest that the whole of the chromatin is not directly concerned with the transformation from the resting reticulum to the compact chromosome condition of the metaphase.

20. The extreme posterior end of the follicle contains numerous degenerating cells, in which irregularly shaped masses of chromatin stain deeply with the iron hæmatoxylin.

21. Although the individuality of the chromosomes is completely lost in the resting-stages of the spermatogonia, spermatocytes, and spermatids, with the one exception of the heterotropic chromosome in the primary spermatocyte growth-period, there is strong reason for supposing that the same elements appear on the successive mitotic spindles throughout development. It is possible that the component granules of a particular chromosome are not the same in these cases, for an exchange of chromatin particles may occur during the reticulum stages, and if this occurs we have at present no means of discovering the extent of this exchange. It must, therefore, not be assumed that corresponding chromosomes of two successive metaphases contain the same individual chromomeres.

In conclusion, I offer my thanks to Prof. Hickson and his staff for placing the research laboratories of Victoria University at my disposal, and for the encouragement that I have received in carrying out this research.

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October 1910.

EXPLANATION OF THE PLATES.

The original drawings were made with the aid of a large Abbe camera lucida, and are reproduced here at the same magnification. All the figures are magnified 2500 diameters, except figs. 1 and 2, which are magnified only 750 diameters. The preparations were studied by means of a Zeiss apochromatic oil-immersion objective of 2 mm. focus and N.A. 1·30, and compensating oculars Nos. 6, 12, and 18. Illumination was obtained from an acetylene burner, the light being directed on to the mirror through a globe condenser containing a weak aqueous solution of copper acetate.

All the drawings shown are made from preparations fixed with Perenyi's fluid and stained with Heidenhain's iron hæmatoxylin, and in certain cases counterstained with eosin. The sections were cut to a thickness of 10 μ. I have endeavoured to render comparison between the successive stages easy by adopting this plan of drawing the figures to the same magnification.

PLATE 1.

Fig. 1. Cyst containing apical cell surrounded by a single layer of primary spermatogonial cells. The lobulate appearance of the distally placed nuclei of the latter is very noticeable. The apical cell's nucleus exhibits the irregular masses of chromatin and the peculiar cluster of deeply staining granules.

Fig. 2. Cyst containing a cluster of secondary spermatogonia, and recognizable by the absence of the apical cell.

Fig. 3. Secondary spermatogonial metaphase, seen from one pole. The seventeen chromosomes are paired, and can be divided into three groups as regards size. The heterotropic chromosome is the fourth largest, and is marked **X**.

Fig. 4. Ditto.

Fig. 5. Lateral view of secondary spermatogonial telophase. The heterotropic chromosome has divided late.

Fig. 6. Resting- or growth-stage immediately following secondary spermatogonial mitosis. The ordinary chromosomes have become resolved into an apparent reticulum, in

which their individuality is lost: the heterotropic chromosome is seen in its characteristic form as a darkly staining body apposed to the nuclear membrane. The nucleus is here at its smallest volume.

Fig. 7. The same at a later stage. The growth of the nucleus is very noticeable.

Fig. 8 Beginning of primary spermatocyte prophase. The reticulum has become converted into a highly convoluted spireme, the heterotropic chromosome remaining as a homogeneous mass apposed to the nuclear wall.

Fig. 9. Later prophase of primary spermatocyte. The spireme has broken into filaments, which have become more darkly stained by the closer association of their component granules. These filaments are shortening and thickening and have begun to assume the characteristic ring and boomerang shapes. A nucleolus is shown above the heterotropic chromosome.

Plate 2.

Figs. 10–19. Chromatin filaments twisted into crosses, rings, and single or double loops; they have become shorter and more condensed than they appeared in the last figure, and will shortly transform themselves into the smooth and compact chromosomes of the metaphase complex.

Fig. 20. Polar view of the primary spermatocyte metaphase—the first maturation division,—showing the nine chromosomes, again divisible into large, small, and medium-sized chromosomes. The heterotropic is still the fourth largest and is marked with a cross.

Fig. 21. Lateral view of the primary spermatocyte metaphase. The ordinary chromosomes are arranged on the mitotic spindle, and the heterotropic chromosome has already passed to the lower pole.

Fig. 22. Ditto.

Fig. 23. Lateral view of the later anaphase of the primary spermatocyte division. The ordinary chromosomes have begun to move towards the opposite poles, but are still attached to one another by the connecting fibrils. The heterotropic chromosome has passed to the upper pole without division. All the chromosomes are shown.

Fig. 24. Lateral view of the primary spermatocyte telophase, showing the massing of chromosomes at the two poles of the spindle.

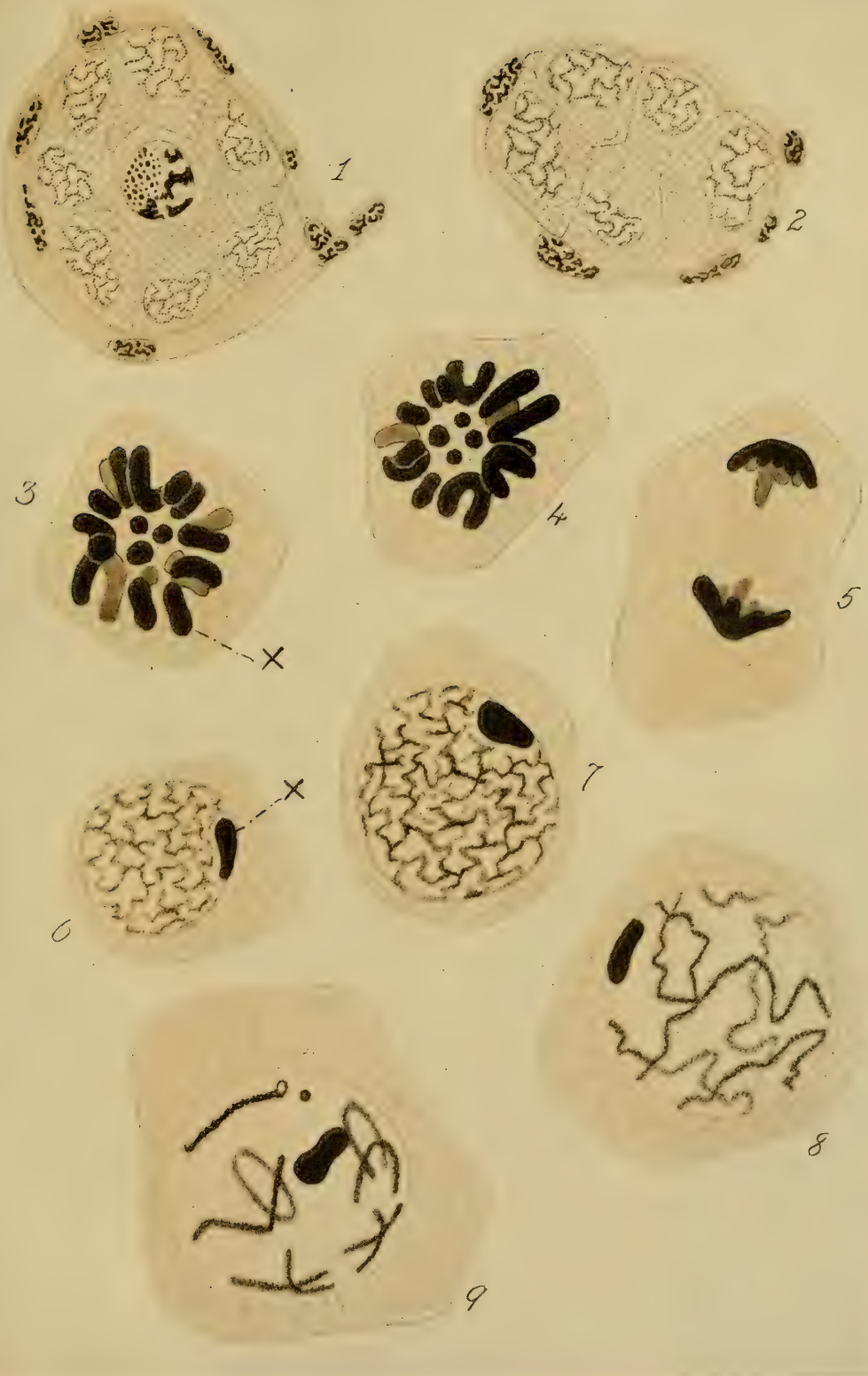
Fig. 25. Polar aspect of the secondary spermatocyte metaphase. The nine chromosomes are exhibited, and are again divisible into three small, three large, two medium, and the odd heterotropic chromosome. Two of the small chromosomes are spherical and the third ovoid; the remainder are seen as a pair of arms joined at one extremity and closely apposed to one another.

Figs. 26, 27. Ditto. It must not be forgotten that the heterotropic chromosome only occurs in 50 % of these cells.

Plate 3.

Fig. 28. Lateral view of the secondary spermatocyte mitosis—the second maturation division. The heterotropic chromosome is seen on the spindle, with its halves attached to one another by the connecting fibrils, thus appearing as the "lagging" chromosome. The ordinary chromosomes are assembled at the two poles.

Fig. 29. Resting-stage of the spermatid. The ordinary chromosomes have become resolved into their component chromatin particles and have lost their identities; the heterotropic chromosome has become ragged through the same process, but can still be recognized. It is marked X.



SPERMATOGENESIS IN STENOBOTHRUS.

Grout sc. & imp.



SPERMATOGENESIS IN STENOBOTHRUS.

Grout sc. & imp.



SPERMATOGENESIS IN STENOBOTHRUS.

Grout sc. & imp.

Fig. 30. Later stage of spermatid. The "centrosome" has appeared, and the axial filament is growing out near its constriction. The cytoplasm below the "centrosome" has begun to elongate into the tail.

Fig. 31. Ditto. In this later stage the chromatin particles of the nucleus have become so minute that their individuality is lost.

Fig. 32. A later stage of the above. The nucleus is elongating and is becoming darker. The reduction in size of the "centrosome" is noticeable.

Fig. 33. Ditto.

Fig. 34. The elongation of nucleus and cytoplasm of tail has transformed the spermatid into an unripe spermatozoon. The reduction of the "centrosome" is very marked.

Fig. 35. Ditto.

Fig. 36. Final stage before transformation into the ripe spermatozoon. The darkly stained nucleus is forming the head, the "centrosome" the middle piece, and the axial filament with its surrounding cytoplasm the tail. The "centrosome" has become considerably smaller than it appeared in fig. 35.

A Comparison of the Summer Plankton on the West Coast of Scotland with that in the Irish Sea.

By Prof. W. A. Herdman, D.Sc., F.R.S., F.L.S.

[Read 3rd November, 1910.]

During the last four summers (1907–1910, incl.) I have spent the first few weeks (July) of the vacation in taking plankton hauls from the

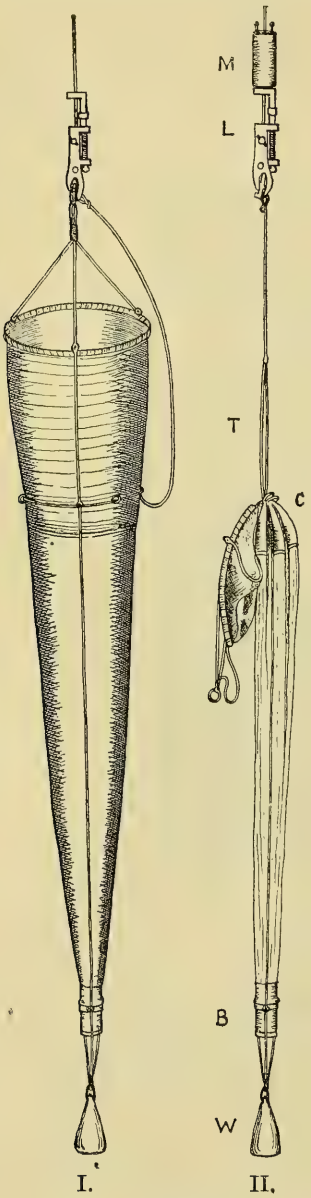


Fig. 1.—"Nansen" Closing Tow-net in action.

I. Open, as it descends and as it fishes.

II. Closed, as it is hauled in after fishing.

M, messenger to effect closing;

L, releasing apparatus;

T, throttling noose;

C, canvas front to net;

B, brass bucket containing the catch;

W, weight.

S.Y. 'Ladybird' amongst the islands and sea lochs of the west of Scotland, and the remainder of the time (in August and September) in similar work

further south, in the Irish Sea. A comparison of the collections leads one to the conclusion that in addition to seasonal changes there may be marked local differences in the plankton, so much so as to give a characteristic appearance to the gatherings from certain localities.

The plankton hauls from the yacht were in all cases taken with the same nets and in the same method, and the after-treatment was also always the same ; so that the various gatherings are as nearly comparable as is possible. All the vertical hauls were made with the smaller "Nansen" net, a closing-net (fig. 1) of no. 20 silk, with the mouth 35 cm. in diameter.

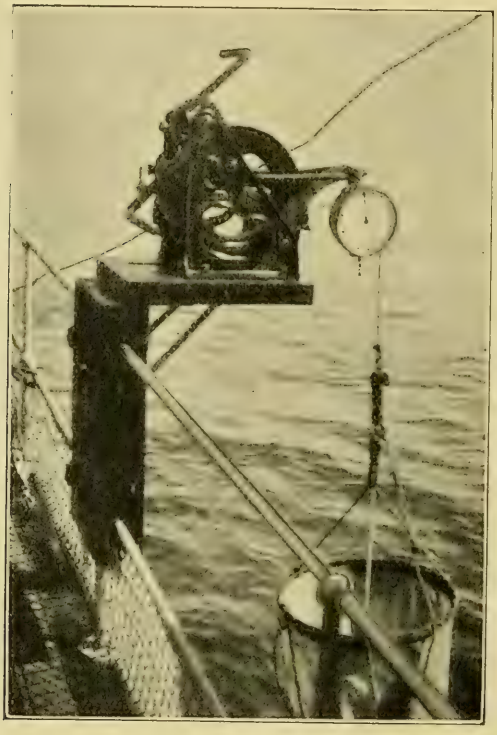


Fig. 2.—Lucas Sounding-Machine as used with Nansen Vertical Closing Net on 'Ladybird.'

Surface gatherings were sometimes taken at the same time with ordinary open surface tow-nets made of the same silk as the "Nansen" net and of approximately the same size. The Lucas Sounding-Machine (fig. 2) fitted with 200 fathoms of pianoforte wire was found to be most convenient and expeditious in taking these deep vertical hauls.

The temperature of the surface water of the sea in the Hebrides varied this summer during the month from 11·8° C. on July 11th, off Canna, to

13·1° C. on July 19th, off the N. point of Eigg. During the same period the surface temperature off Port Erin in the Irish Sea ranged from 11·6° C. to 13·8° C.

As my main object was to obtain samples of vertical hauls from the deeper parts of the British seas, I selected localities off the West Coast of Scotland where the charts showed depths of over 50 fathoms, and where possible of over 100 fathoms. In addition to surface gatherings and the Irish Sea series, I have now 33 successful vertical hauls in Scottish waters from depths of over 50 fathoms and 18 from over 100 fathoms (see fig. 8, p. 38) The deepest are :—133 fathoms, between Croulin and Longa Islands in the Sound of Raasay, and 130 fathoms between Canna and Rum, south of Skye.

The localities may conveniently be grouped in three series : (1) those north of Oban, (2) those further south in the Clyde sea-area, and (3) those in the Irish Sea. The northern Scottish series number 41, the southern series 26, and those from the Irish Sea, from depths over 50 fathoms, are 66 *. The list of localities is as follows, arranged according to the day of the month irrespective of years :—

I. North of Oban.

(1) 11–vii–'10 ; Hyskeir, S. of Canna ; surf. (2 hauls).
(2) 12–vii–'10 ; Vatersay Sound ; surf. (2 hauls).
(3) 13–vii–'09 ; Ardmore, N. of Mull ; 94 faths.
(4) 13–vii–'09 ; Between Canna and Rum ; 130 faths.
(5) 14–vii–'09 ; Loch Nevis, Sd. of Sleat ; 75 faths.
(6) 14–vii–'10 ; N. of Canna ; 80 and 105 faths.
(7) 14–vii–'10 ; Between Canna and Rum ; 128 faths.
(8) 15–vii–'09 ; L. Hourn, Sd. of Sleat ; 76 and 90 faths.
(9) 16–vii–'09 ; Between Croulin and Longa, N. of Skye ; 133 faths.
(10) 17–vii–'08 ; Loch-na-Beist, Skye ; 6 faths. all night.
(11) 17–vii–'08 ; L. Nevis, Sd. of Sleat ; over 70 faths. (2hauls).
(12) 17–vii–'08 ; L. Hourn ; 43, 45, 73, and 78 faths.
(13) 17–vii–'09 ; L. Duich ; 61 faths.
(14) 18–vii–'08 ; Holm Isle, Sd. of Raasay ; 65 and 70 faths.
(15) 18–vii–'08 ; L. Ainnert ; 20 and 23 faths.
(16) 18–vii–'08 ; L. Sligachan ; 12 faths.
(17) 18–vii–'10 ; Ardmore, N. of Mull ; 65, 74, and 85 faths.
(18) 19–vii–'10 ; N.W. of North Pt. of Eigg ; 85 faths.
(19) 20–vii–'08 ; Longa Island ; 106 faths.
(20) 20–vii–'08 ; S. of Croulin Isles ; 116 faths.
(21) 21–vii–'07 ; Sd. of Iona ; surf.
(22) 21–vii–'09 ; Bernera I., Lynn of Morven ; 110 faths.
(23) 21–vii–'09 ; Between Kerrera and Mull ; 80 faths.
(24) 21–vii–'10 ; L. Sunart ; 57 faths.

* I have also taken about 200 gatherings in these four years (1907–10) from shallower water in the Irish Sea, and these have been reported on fully in Trans. Biol. Soc. Liverpool, vols. xxii–xxiv, 1908–10.

(25) 22–vii–'07 ; Sd. of Iona ; surf.
(26) 22–vii–'10 ; Firth of Lorn ; 108 and 116 faths.
(27) 22–vii–10 ; Bernera I., Lynn of Morven ; 110 faths.
(28) 24–vii–'07 ; L. Scresort, Rum ; surf.

II. Clyde Sea Area.

(1) 18–vii–'07 ; Skate I., L. Fyne ; 104 faths.
(2) 26–vii–'07 ; Kilbrennan Sound ; 76–80 faths.
(3) 27–vii–'07 ; East L. Tarbert, off Buddhe I. ; 76 faths.
(4) 27–vii–'07 ; off Cock of Arran ; 76 faths.
(5) 27–vii–'07 ; L. Ranza, Arran ; night ; surf.
(6) 28–vii–'08 ; Skate I., L. Fyne ; 95–105 faths. (3 hauls), and surf.
(7) 28–vii–'08 ; off Mt. Erins, L. Fyne ; 83 faths.
(8) 28, 29–vii–'08 ; Newton, Upper L. Fyne ; 54–66 faths. (4 hauls).
(9) 28–vii–'09 ; Skate I., L. Fyne ; 100–106 faths. (4 hauls).
(10) 29–vii–'09 ; Upper L. Fyne ; 70 faths.
(11) 30–vii–'09 ; Sd. of Bute ; 95 faths.
(12) 30–vii–'08 ; L. Ranza, Arran ; surf.
(13) 30–vii–'09 ; off Cock of Arran ; 80 faths.
(14) 31–vii–'08 ; S. of Holy I., Lamlash, Arran ; 54 faths. (2 hauls).
(15) 1–viii–'09 ; off Portpatrick ; 103 and 106 faths.
(16) 1–viii–'10 ; off Sannox, Arran ; 70 faths.

III. Irish Sea.

(1) 7–iv–'09 ; 60 faths. (4 hauls).
(2) 8–iv'–09 ; 60 faths. (5 hauls).
(3) 6–viii–'09 ; 59–60 faths. (5 hauls).
(4) 7–viii–'09 ; 60–70 faths. (4 hauls).
(5) 10–viii–'09 ; 60–73 faths. (4 hauls).
(6) 17–viii–'08 ; 60–70 faths. (6 hauls).
(7) 24–viii–'07 ; 60 faths. (10 hauls).
(8) 25–viii–'10 ; 60 faths. (5 hauls).
(9) 4–ix–'07 ; 60 faths. (12 hauls).
(10) 12–ix–'07 ; 60 faths. (6 hauls).
(11) 12–ix–'08 ; 60 and 70 faths.
(12) 17–ix–'10 ; 70 faths. (3 hauls).

As the same spot was sometimes visited in successive years, many of the gatherings in the list above may be grouped under a few localities, as follows :—

I. North of Oban.

1. Off Ardmore Pt. in Mull—gatherings : (3) in 1909, and (17) in 1910 (3 hauls).
2. Loch Hourn—gatherings : (12) in 1908 (4 hauls), and (8) in 1909 (2 hauls).
3. Loch Nevis—gatherings : (11) in 1908 (2 hauls), and (5) in 1909.
4. Canna, Rum, etc.—gatherings : (4) in 1909, and (6) (2 hauls) and (7) and (18) in 1910.
5. Croulin and Longa—gatherings : (14) (2 hauls) and (19) and (20) in 1908, and (9) in 1909.
6. Firth of Lorn, etc.—gatherings : (22) and (23) in 1909, and (26) (2 (hauls) and (27) in 1910.

II. Clyde Sea Area.

7. Skate Island—gatherings: (1) in 1907, (6) (3 hauls) and (7) in 1908, and (9) in 1909 (4 hauls)
8. Upper Loch Fyne—gatherings: (8) in 1908 (4 hauls), and (10) in 1909.
9. Arran, Sound of Bute, etc.—gatherings: (2), (3), and (4) in 1907, (11) and (14) (2 hauls) in 1908, (13) in 1909, and (15) in 1910.

III. Irish Sea.

10. All the 58 hauls were in the one locality, 12–16 miles N.N.W. of Port Erin, Isle of Man, from depths of 59 to 73 faths.

When we examine these groups of Scottish gatherings from the same places in different years, two conclusions become evident :—

(1) That localities, in some cases not very far apart, differ very considerably in the nature of their plankton at the same time of year ;

(2) That there is a constancy year after year in the nature of the plankton at some localities.

A few examples will make this clear :—

(1) In the northern area, the hauls taken in Loch Hourn and Loch Nevis are on all occasions very different from those taken off Ardmore in Mull, and from those taken off the Island of Canna ; also those taken in the Lynn of Morven at one end of the Sound of Mull differ from those taken between Mull and Ardnamurchan at the opposite end. Again, in the southern series, the hauls from off Skate Island, in the entrance to Loch Fyne, differ markedly from those taken further south in the Sound of Bute and the Firth of Clyde off Arran.

(2) The Loch Fyne vertical hauls are always characterised by the abundance of large Copepoda ; the hauls off Canna and elsewhere in the Sea of the Hebrides by the prevalence of Diatoms ; those in the Firth of Lorn by a fine zoo-plankton, and those round Raasay on the North of Skye by a much coarser zoo-plankton.

Let us now examine some of these cases in more detail :—

All the vertical hauls taken in the deep hole, 95–106 faths., off Skate Island at the mouth of Loch Fyne, consist of a coarse zoo-plankton (see fig. 3) characterised by a very great number of the common Copepod, *Calanus helgolandicus*. The specimens of *Calanus* are large, and many of them are of a red colour when alive ; and associated with them are generally a few *Euchæta norvegica* and one or two specimens of the Schizopod *Nyctiphanes norvegicus*. There are also in these hauls a few smaller Copepoda (such as *Pseudocalanus elongatus* and *Oithona similis*), some Copepod eggs and nauplii,

a few Sagitta, a few Echinoderm Plutei and Polychæt Larvæ, *Ceratium tripos*, and some Diatoms, chiefly *Rhizosolenia semispina*. But the bulk of the gathering is, in all cases, *Calanus helgolandicus*, and that gives it a characteristic appearance which can be seen as soon as the net comes up. We have in all eight vertical hauls taken during July in the years 1907, –08, –09, and also a surface gathering taken at the same locality on July 28th, 1908. This surface gathering is, however, of an entirely different character from the vertical hauls. It is greenish in colour, and of fine flocculent appearance, and is in constitution a phyto-plankton (see fig. 4) almost entirely composed of Diatoms, chiefly species of *Rhizosolenia*. There are also a few Peridinians,

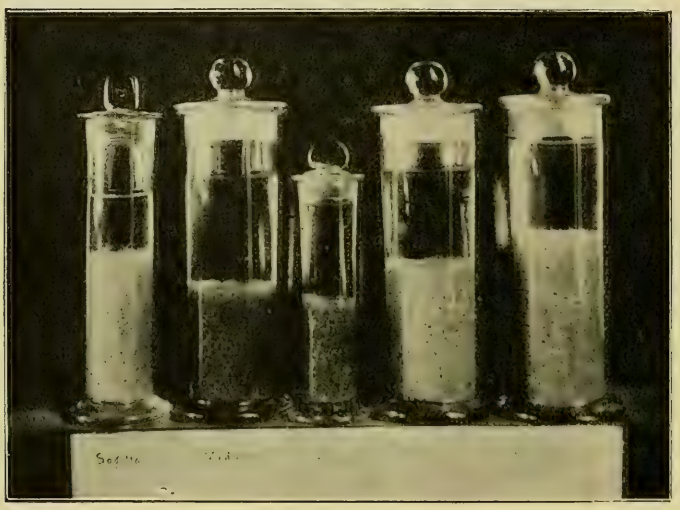


FIG. 3.—Monotonic Zoo-plankton samples, one of which shows *Calanus*.

and a very few small Copepoda, but the larger Copepods characteristic of the vertical hauls are entirely absent.

A vertical haul from 83 faths. taken off Mt. Erins, further up Loch Fyne, on that same date in July, 1908, shows the same type of gathering as the vertical hauls off Skate Island.

It is clear that the *Calanus* population extends in the deep water along the length of Loch Fyne, as hauls taken at various points in Upper Loch Fyne, both in 1908 and 1909, from depths of 54–70 faths., show the same kind of gatherin gas those off Skate Island. On the other hand, in working down the channel towards Bute, Arran, and Kilbrennan Sound, we find that the gatherings are of a more varied nature. One off Sannox, Arran, on August 1st, 1910, from 70 faths., is a mixture of phyto- and zoo-plankton, and does not contain the large Calanoid Copepoda in any quantity. A haul taken off the Cock of Arran at the same season in the previous year, from a

depth of 80 faths., had a fair number of large Copepoda, mixed, however, with Diatoms (*Rhizosolenia semispina*, *Chætoceros boreale*, &c.), Peridinians, and some smaller Copepoda. Another haul in the same spot in 1907 is of the same nature, with a still larger proportion of the smaller Copepoda (mainly *Pseudocalanus elongatus* and *Oithona similis*) and their Nauplii. One in the Sound of Bute from a depth of 95 faths., on July 30th, 1908, had along with the Calanoids, and some smaller Copepoda, a very large number of Diatoms (chiefly species of *Rhizosolenia*), so as to be almost a phyto-plankton in appearance. Two hauls taken south of Holy Island, Arran, from 54 faths., in 1908, show also a mixed plankton, consisting of Diatoms and Peridinians along with the Copepoda. A haul from 80 faths.

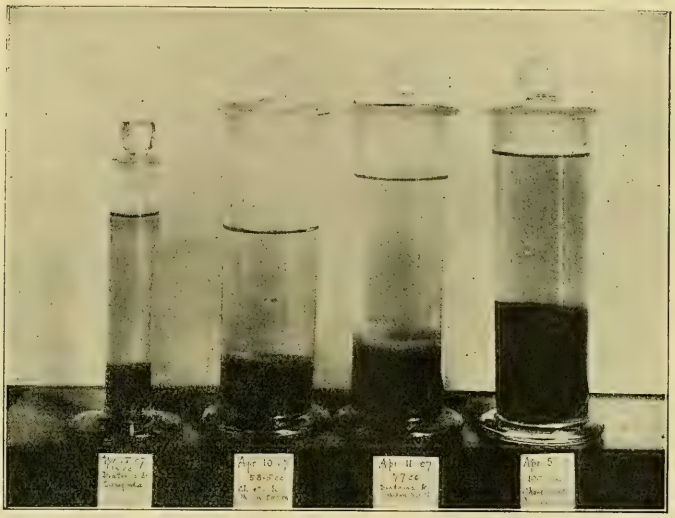


Fig. 4.—Samples of Phyto-plankton from the Irish Sea, about the time of the vernal maximum.

in Kilbrennan Sound on the west of Arran, on July 26th, 1907, consists of a coarse zoo-plankton, in which, however, there are many small Copepoda (*Pseudocalanus* and *Oithona*) and other animals (*Oikopleura* and larval forms) and a few Peridinians and Diatoms (*Rhizosolenia semispina*), mixed with the large Calanoid Copepods.

There are four vertical hauls taken in 1908 and 1910 off Ardmore, Mull, in the centre of the channel between Mull and Ardnamurchan. These and a vertical haul taken in the neighbouring Loch Sunart, in 1910, are all alike in general character, consisting of a fine greenish phyto-plankton mixed with some small Copepoda and a few *Oikopleura*. The Diatoms are, in all cases, mostly species of *Chætoceros* (*C. contortum* and *C. decipiens*) and of *Thalassiosira* (*T. gravida* and *T. Nordenskioldii*).

Again, the six hauls taken in Loch Hourn, off the Sound of Sleat, a little further up the coast, and the three taken in the closely adjacent Loch Nevis are all very much alike in character, but differ from those of Mull; consisting, as they do, of small catches of zoo-plankton composed mainly of small Copepoda, some young *Nyctiphanes*, *Sagitta*, Polychæt larvæ, a few Peridinians, and many Tintinnidæ.

The gatherings taken inside these neighbouring lochs in the mainland contrast markedly with hauls taken at the same time of year in the open sea further west, *e. g.*, off the Islands of Canna and Rum.

A vertical haul from 85 faths. on July 19th, 1910, between Eigg and Rum, and another on July 14th, from 128 faths., between Canna and Rum, show well-marked green-coloured phyto-plankton ; and other hauls off Canna on July 13th and 14th in the same year, from depths of 80, 105, and

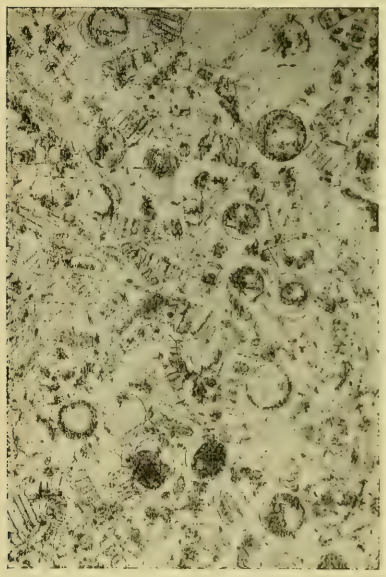


FIG. 5.—A typical Phyto-plankton gathering : from a photo-micrograph by Mr. Edwin Thompson.



FIG. 6.—A typical coarse Zoo-plankton (*Calanus*) : from a photo-micrograph by Mr. Edwin Thompson.

130 faths., are also characteristic phyto-plankton gatherings composed chiefly of common species of *Chætoceros*.

The contrast between such a green Diatom haul taken in the sea of the Hebrides off Canna, in July, and a similarly captured haul at the entrance to Loch Fyne at the same time of year is most marked, the first being a typical fine phyto-plankton (such as fig. 5) and the latter a typical coarse zoo-plankton (fig. 6). As I shall show below, two such gatherings if obtained

in the Irish Sea would be regarded as characteristic of two distinct seasons of the year, months apart.

The difference between the Diatom hauls in the open sea and the fine zoo-plankton hauls in the deep fiords running into the mainland, such as Loch Nevis and Loch Hourn, is not so marked, but is still quite noticeable.

Hauls taken further north, on the other side of Skye, in the Sound of Raasay, off Longa Island and off the Croulins, from depths of 106, 116, and 133 faths., are all zoo-planktons, although not very large or characteristic in appearance. Some are coarser and some finer, some have more Calanoid Copepoda and *Sagitta* and Medusæ than others, but there does not seem to be the constancy of character obtained in some other West Highland localities. Further south, again, in the Firth of Lorne and the Lynn of Morven, off Bernera Island, and between Kerrera and Mull, from depths of 80 to 116 faths., the gatherings, of which we have half a dozen for comparison, are composed of a very fine material, chiefly zoo-planktonic, consisting of small Copepoda, many Nauplii and Tintinnidæ, some *Sagitta* and *Oikopleura*, with a few *Ceratium*, *Peridinium*, and Diatoms; and the latter when present are mainly *Coscinodiscus concinnus* rather than the species of *Chætoceros* and *Thalassiosira* which are so abundant to the north of Mull.

If the hauls from these various localities are marked P or Z, according as they are mainly Phyto-plankton or mainly Zoo-plankton, the list comes out as follows :—

Date.	Depth in Faths.	No. of Hauls.	Zoo- or Phyto-Plankton.	Remarks.
		Off Ardmore, Mull.		
July 13, '09 ..	94	1	P.	With some small Copepoda, Nauplii, &c.
„ 18, '10 ..	65, 74, & 85	3	P.	
		Loch Hourn.		
July 15, '09 ..	76 & 90	2	Z.	
„ 17, '08 ..	73 & 78	4	Z.	
		Loch Nevis.		
July 14, '09 ..	75	1	Z.	
„ 17, '08 ..	70	2	Z.	
		Off Croulin and Longa.		
July 16, '09 ..	133	1	Z.	
„ 18, '08 ..	65 & 70	2	Z.	
„ 20, '08 ..	106 & 116	2	Z.	
		Firth of Lorn.		
July 21, '09 ..	80 & 110	2	Z.	A few Diatoms and Peridinians present.
„ 22, '10 ..	108, 110, & 116	3	Z.	

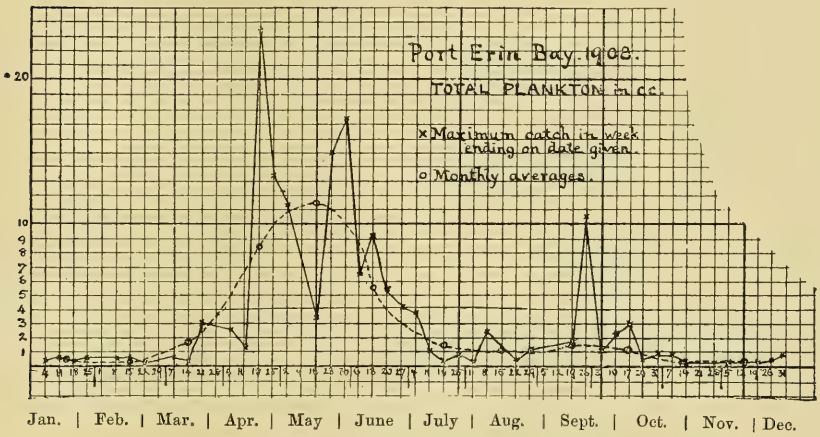
Date.	Depth in Faths.	No. of Hauls.	Zoo- or Phyto-Plankton.	Remarks.
		Off Canna, Rum, &c.		
July 13, '09 ..	130	1	P.	With some small Copepoda and a few other small animals.
„ 14, '10 ..	80, 105, 128	3	P.	
„ 19, '10 ..	85	1	P.	
		Skate Island.		
July 18, '07 ..	104	1	Z.	
„ 28, 08 ..	83 & 95 to 105	4	Z	
„ 28, '09 ..	100 to 106	4	Z.	
		Upper Loch Fyne.		
July 28 & 29, '08	54 to 66	4	Z.	
„ 29, '09....	70	1	Z.	
		Arran, Sound of Bute, &c.		
July 26, '07 ..	76–80	1	Z.	
„ 27, '07 ..	76	1	Z.	
„ 30, '08 ..	95	1	Z. (mixed)	Diatoms also present.
„ 30, '09 ..	80	1	Z.	A few Diatoms.
„ 31, '08 ..	54	2	Z. (mixed)	A few Diatoms and Peridinians.
Aug. 1, '10 ..	70	1	P.	Copepoda, &c., present also.
		Irish Sea.—Mid-Channel.		
Apr. 7, '09 ..	60	4	P.	Typical spring phyto-Plankton.
„ 8, '09 ..	60	5	P.	
Aug. 6, '09 ..	59 to 60	5	Z.	
„ 7, '09 ..	60 to 70	4	Z.	
„ 10, '09 ..	60 to 73	4	Z. (mixed)	A few Diatoms present.
„ 17, '08 ..	60 to 70	6	Z. (mixed)	
„ 24, '07 ..	60	10	Z. (mixed)	
Sept. 4, '07 ..	60	12	Z.	
„ 12, '07 ..	60	6	Z. (mixed)	Diatoms getting more numerous.
„ 12, '08 ..	60 & 70	2	Z. (mixed)	

Thus we have evidence that, off the north-west coast of Scotland at one time of year (July), in several successive years the plankton, as sampled by vertical hauls, was of different types (zoo- and phyto-plankton) in different localities, but preserved a constant character in each.

Now, in the Irish Sea, around the Isle of Man, when the plankton of the whole year is considered, it is clear that neighbouring localities do not present widely different characters as they do in the Hebrides, and that a zoo-plankton and a phyto-plankton do not occur simultaneously a few miles apart. In spring or early summer, in the Irish Sea, as elsewhere, there is an enormous phyto-plankton maximum (see Table, p. 35, column D), which gradually dies away, and is replaced by the zoo-plankton which is characteristic of the summer months (Table, col. E). In September or October, again, Diatoms make their appearance in profusion, constituting a second, autumnal, phyto-

plankton maximum (Table, col. F). The accompanying diagram (fig. 7) shows, *e. g.*, the curve for the whole plankton in the year 1908, as given by a very large series of gatherings *, extending over every month, taken across Port Erin Bay. The high points in April and May, and then again, but to a less extent, in September and October, show the influence of the vernal and autumnal phyto-plankton maxima, and the effect would, of course, be still more marked in the curve showing the Diatoms alone. Taking the average of the last three years in Port Erin Bay, we find that the monthly averages for the total plankton begin low in January and February, rise in March and still more in April, reach the maximum in May, drop rapidly

Fig. 7.



through June, July, and August to the summer minimum, rise a little in September and October to form the autumnal maximum, and fall again in November and December to the mid-winter minimum. The autumnal maximum is always very much less than the vernal, and is sometimes scarcely apparent. Both are caused by a very marked increase in the phyto-plankton, chiefly Diatoms (see lists in Table, p. 35) ; and the species which are the most abundant and characteristic at the two seasons are, for the most part, distinct †. In summer, when the phyto-plankton is practically absent, the zoo-plankton reaches its maximum ; but, in bulk, even at the maximum, the zoo-plankton, except on rare occasions, is small compared with the spring gatherings of phyto-plankton (see columns D and E). A phyto-plankton gathering in the Irish Sea is practically only obtainable in spring or in late autumn ; and if the gathering be a very large one (like D in the Table), it is

* See Trans. Biol. Soc. Liverpool, vol. xxiii. p. 244 (1909).

† See *op. cit.* vol. xxii. p. 202 (1908).

certain to have been taken at the former period, say, between the middle of March and the middle of May.

But in the Hebrides, as we have seen, very large phyto-plankton hauls may be taken year after year in July—when in the Irish Sea the hauls are, for the most part, comparatively small, and are all composed of zoo-plankton. Mr. Andrew Scott, A.L.S., who has been associated with me for some years in studying the plankton of the Irish Sea, remarked, when I showed him some of the phyto-plankton samples from Canna, Rum, and Ardmore: "If I had not seen the locality and date on the bottles, I should have placed them, without doubt, as Irish Sea gatherings taken in April." And the resemblance, I may add, is not merely in general appearance, but extends to the microscopic composition. The gatherings from Ardmore, for example, contain abundance of *Chætoceros contortum* and *C. decipiens*, *Rhizosolenia semispina*, *Lauderia borealis*, *Thalassiosira gravida*, and *T. Nordenskiöldii*—all of them Diatoms that are characteristic of an April gathering in the Irish Sea, off Port Erin. The abundance of the two species of *Thalassiosira* makes this and other July gatherings from round Canna and Mull quite unlike a September Diatom haul in the Irish Sea, as the genus *Thalassiosira*, abundant in the North, is practically absent at the time of the autumnal maximum in the South.

In order to demonstrate still further the characters of these diverse planktons, and illustrate the comparison between the Scottish summer series and Irish Sea gatherings typical of different seasons, I give on p. 35 in tabular form the quantitative details * of :—

(A) A typical coarse zoo-plankton from off Skate Island at the entrance to Loch Fyne, July 18th.

(B) A zoo-plankton of somewhat different type (with fewer *Calanus*, but many more of the smaller Copepoda), from Kilbrennan Sound, July 26th.

(C) A mixed gathering, mainly phyto-plankton, from off Loch Ranza, Arran, July 27th.

These three somewhat diverse samples were obtained, it will be noticed, within a period of ten days, in July, from localities not ten miles apart.

I add also, for comparison, the similar quantitative record of three characteristic gatherings made in the centre of the Irish Sea, off the west coast of the Isle of Man, near Port Erin, as follows :—

(D) A typical phyto-plankton, taken in April—a large haul (100 c.c.).

(E) A typical scanty zoo-plankton, from August (2·5 c.c.).

(F) A mixed gathering, mainly phyto-plankton, in September, when the autumnal Diatoms are present in quantities (11 c.c.).

* The enumeration of the species in these quantitative lists was made by Mr. Andrew Scott, A.L.S., for our joint report on the Irish Sea plankton. I am indebted to my friend Mr. Edwin Thompson for the photo-micrographs from which figs. 5 and 6 were prepared.

	West of Scotland.			Irish Sea.		
Locality	L. Fyne.	Kilbrennan.	L. Ranza.	P. Erin.	P. Erin.	P. Erin.
Date	July 18.	July 26.	July 27.	April 5.	Aug. 21.	Sept. 12.
Depth in fathoms	104	76–80	0	20–10	20–0	0
Catch in c.cm.	30	28	11	100	2·5	11
	A	B	C	D	E	F
Asterionella Bleakeleyi	...	...	...	15,000	...	1,200
Biddulphia mobiliensis	...	...	...	15,000	25	...
Chætoceros contortum	...	...	...	14,000,000	...	...
,, debile	...	...	500	...	...	3,000
,, decipiens	100	...	4,500	50,000	...	8,000
,, teres	100	...	...	50,000	...	60,000
,, subtile	300	...	3,000	...	...	140,000
,, boreale	...	500	5,500	...	...	...
,, densum	...	...	1,000	...	...	...
Coscinodiscus concinnus	...	...	...	15,000	...	2,500
,, radiatus	...	...	500	...	...	1,250
Ditylium Brightwellii	...	...	...	...	...	2,500
Eucampia zodiacus	...	...	...	...	...	4,000
Melosira Borreri	...	...	...	...	...	5,000
Rhizosolenia semispina	800	15,500	1,735,000	...	...	16,000,000
,, Shrubsolei	...	...	4,000	...	...	20,000
,, Stolterfothii	...	...	15,000	...	...	30,000
Thalassiosira gravida	...	...	...	90,000	...	...
,, Nordenskiöldii	...	...	...	2,000,000	...	...
Lauderia borealis	...	...	...	600,000	...	120,000
Leptocylindrus danicus	...	...	500	...	...	...
,, sp.	...	...	...	...	...	50,000
Pleurosigma sp.	...	...	500	...	...	...
Rhizosolenia setigera	...	...	...	...	...	2,500
,, alata	...	...	...	...	...	150,000
Trochiscia sp.	...	...	1,000	...	...	...
Ceratium furca	...	...	...	...	...	7,500
,, fusus	...	...	500	...	25	17,000
,, tripos	800	6,000	2,500	...	100	50,000
Peridinium sp.	...	2,500	300	...	50	...
Medusoid gonophores	1	...	150	...	...	7
Plutei of Echinoderms	200	500	1,250	...	...	...
Sagitta bipunctata	2	15	...	...	30	...
Larval Polychæta	100	...	...	...	...	...
"Mitraria"	200	1,000	1,500	...	...	...
Crab zoea	20	...	...	6	...	...
Podon intermedium	20	100	...	...	20	...
Evadne nordmanni	100	1,600	1,250	...	...	...
Calanus helgolandicus	13,000	4,600	50	...	10	11
Pseudocalanus elongatus	3,460	48,700	150	250	300	60
Temora longicornis	20	200	...	225	65	...
Centropages hamatus	...	500	100	...	5	20
,, typica	120	...	...	...	...	...
Acartia clausi	240	1,000	200	300	110	900
Oithona similis	1,880	11,000	1,250	200	1,000	250
Paracalanus parvus	...	...	...	...	...	80
Copepod nauplii	12,000	18,500	45,000	...	2,000	9,000
,, Juv.	8,000	48,500	15,000	...	500	3,800
Gasteropods, larval	...	500	500	...	25	...
Lamellibranchs, larval	...	500	600	...	50	...
Oikopleura sp.	30	1,000	600	1,500	500	10

It will be noticed, in comparing the Loch Ranza plankton with the Irish Sea hauls in April and September, that in species present and their abundance, the Scottish July gathering is much more like the September than the April phyto-plankton—for example, in both July and September the most abundant form is *Rhizosolenia semispina*, a species absent in April. But, as has been pointed out above, the phyto-plankton gatherings north of Mull show resemblances to the vernal rather than to the autumnal phyto-plankton of the Irish Sea.

It is probably premature to hazard any suggestion as to the explanation of this curious difference between the summer planktons in the Hebridean and the Irish Sea respectively. It may be that the great vernal maximum which dies away in May and June in the Irish Sea passes off more slowly further north, and is still found lingering on in some parts of the Hebrides until the end of July, or possibly even longer. Or it may be that, in some of these deep northern channels, the Diatoms that elsewhere constitute our vernal maximum remain on in comparative abundance throughout the greater part of the year. Still a third possible explanation is that the Diatoms constituting these July phyto-plankton gatherings may have invaded the Hebridean seas from the North Atlantic at some period subsequent to the vernal maximum. It is obvious that such a question can only be determined by frequent periodic observations carried on throughout the year by means of vertical hauls at fixed localities. Such series of observations have still to be made in the Scottish seas. Mr. George Murray, in 1896, took some series of horizontal tow-net gatherings at various localities round the coast of Scotland for the Scottish Fishery Board, and he published a brief report* the following year on his results. His observations were made in March, July, August, and December, and were widespread, including several of the localities I have sampled ; but they seem to deal mainly, if not wholly, with the surface of the sea, and in any case do not include vertical hauls in deep water. But it is interesting to note that his results, so far as they go, are not inconsistent with the observations I have given above. Murray states that after the vernal maximum the Diatoms diminish, but do not disappear, and are to be found throughout the summer in local banks. *Skeletonema costatum* he notes as the most abundant and characteristic form on the surface generally in April, and in Loch Etive in August: this species occurred only occasionally in our July hauls.

The table he gives shows that there were fewer species of Diatoms in Loch Nevis and Loch Hourn than in the sea between Rum and Ardnamurchan—there being 28 in the latter column and only 7 in that for Loch Nevis. So far this comparison agrees with the abundant phyto-plankton gatherings we obtained off Rum and Canna, &c., and the comparatively small catches

* S. F. B. Report for 1896, vol. xv. part iii. p. 212.



FIG. 8.—West Coast of Scotland, showing depths of over 50 (shaded) and over 100 (black outline) fathoms. Twenty-five stations at which deep hauls were taken are marked by a small black circle enclosing a cross.

of zoo-plankton in the lochs on the mainland; but our hauls being vertical from the bottom at great depths probably sampled a much larger body of phyto-plankton, and included some species that did not appear at the surface.

It may be added that Prof. P. T. Cleve gave a short account, in the Scottish Fishery Board's Report for 1896, p. 297, of the phyto-plankton of the 'Research' collections made in the Shetlands, and showed that the stations on the western side were rich in Diatoms, while the hauls taken from the east of the islands were much poorer—this, again, showing a difference between not very distant localities at the same time of year.

The Scottish Fishery Board do not seem to have published any further investigations in regard to plankton in their western seas; nor does the Irish Fishery Department give any information in regard to the minuter plankton of the seas between Scotland and Ireland: apparently only coarse-meshed nets have been used by the Irish investigators, and no Diatoms are given in the published tables (Conseil Per. Internat., Bull. Trimestriel, 1907–8, Copenhague, 1909), which deal with zoo-plankton alone. Finally, the map giving the stations in European seas at which plankton observations have been taken in recent years (*loc. cit.*, Résumé Planktonique, Introduction, p. xii, 1910) shows a great gap extending from near Cape Wrath, in the north of Scotland, to Belfast Lough in Ireland. The whole of the seas around the Western Islands of Scotland, like the western coasts of England and Wales, have apparently been omitted from the Official Internationa investigation.

This is, from the scientific point of view, most unfortunate, as, for a complete understanding of the plankton changes throughout the year, in the Irish Sea at least, it would be useful, and may be essential, to have information as to the planktonic conditions month by month on the north coast of Ireland and on the west coast of Scotland.

The unofficial observations recorded in this paper have shown that, while the abundant vernal phyto-plankton dies away in the Irish Sea in early summer, a similar micro-flora is present in quantity in some parts of the sea on the west of Scotland (*e. g.*, the Sound of Mull, and the sea round Canna, Eigg, &c.) until July, and possibly latter. It can scarcely be doubted that the phyto-plankton maximum is found in spring in the Hebrides as in the Irish Sea. But have the July Diatoms remained since April, or did they die off (as they do further south) and then re-appear? If the latter, have they come from the Atlantic or from northern seas? Do they continue to be abundant throughout the remainder of summer and autumn? Are any of them left in the deeper channels in winter? These and many other problems press for solution, and will probably only be solved by continuous plankton work throughout the year at a series of stations along our western coasts.

On some Hexactiniæ from New South Wales.

By Leonora J. Wilsmore, M.Sc., Zoological Laboratory, University College, London. (Communicated by Prof. J. P. Hill, D.Sc., F.L.S.)

(Plates 4–6 and one Text-figure.)

[Read 16th February, 1911.]

In this paper I continue a description of the Actiniaria brought from Australia by Professor J. P. Hill, to whom I am indebted both for material and for kindly advice and assistance. The classification employed is that adopted by Haddon in "The Actiniaria of Torres Straits," (17) 1897. In the present communication the following species are classed as new :—

Hexactiniæ, Hertwig.
Family Ilyanthidæ, Gosse.
Subfam. Halcampinæ, Kwietn.
Peachia hilli, sp. n.
Family Sargartiidæ.
Subfam. Phellinæ, Verr.
Phellia browni, sp. n.
Phellia capitata, sp. n.

Peachia hilli. (Pl. 4. figs. 1–8.)

Form (Pl. 4. figs. 1 & 2).—The two specimens I received differ very much in size and outward appearance. The internal anatomy, however, shows that they undoubtedly belong to the same species, the smaller form being larval. The body consists of three parts—capitulum, scapus, and physa. There is no distinct division between the capitulum and scapus ; but the physa is clearly defined, and in the adult appears as a small bud at the posterior end of the scapus (Pl. 4. fig. 1, *p.*). It measures 1·5 mm. in length, and shows none of the external grooves present in the physa of *Peachia hastata* (7), but their absence may be due to contraction. The peculiar form in which the posterior end of the scapus has contracted in the adult has no reference to its internal anatomy (Pl. 4. fig. 1, *s.*). The physa in the larval form is introverted, so that there appears to be a large pore at the posterior end. This is evidently the "anus large and conspicuous" of *Peachia carnea*, described by Professor Hutton (6). The entire surface is covered with minute projections, which are also characteristic of *Peachia hastata*. Professor Haddon (7) describes them as

suckers which "enable the anemone to hold itself upright against any smooth surface." Faurot appears to refer to the same projections as "pli de contraction" (15). A series of white, irregular, longitudinal lines are visible through the external walls of the scapus and capitulum. They agree in number with the mesenteries, and probably correspond to the insertion of the mesenteries in the column. Other lines, shorter, more irregular, and transverse, fill in the spaces between the longitudinal ones. In both polyps the œsophagus is partly extruded, so that description of mouth or disc is impossible. In the adult (Pl. 4. fig. 1, *œs.*), folds of the œsophagus envelop the oral end of the siphonoglyphe, and the tentacles—twelve, marginal, monocyclic, short and obtuse—are also largely concealed. The only one fully visible measures 2·5 mm. In the larval form (Pl. 4. fig. 2) the capitulum is retracted, and the single row of tentacles (Pl. 4. fig. 2, *tent.*), which vary in length from 1–1·5 mm., is fully visible with a crown of lobes above them. These lobes are the extruded œsophagus (Pl. 4. fig. 2, *œs.*), which, being held back at regular intervals by the mesenteries attached to the œsophageal walls, appears to be lobed.

It is characteristic of the genus *Peachia* that the tube of the siphonoglyphe ends orally in a conchula or external opening, independent of the mouth, the shape of this conchula varying in the different species (13). The siphonoglyphe is present as an open tube in both these examples of *Peachia*; hence the separate conchula is not present. In the adult the oral end of the siphonoglyphe is unfortunately not distinguishable from the loose folds of the extruded œsophagus which envelop it. The larval siphonoglyphe, visible to the naked eye, forms a deep, open, thick-walled gutter between two lobes of the œsophagus, and ends in simple thick rounded lobes which would form two complete lips were the gutter to close as a tube. Possibly in both specimens the degree of contraction has caused the tube to open.

Colour.—Sandy in spirit-specimens. Professor Hill states that it was cream-coloured when alive.

Dimensions.—Adult: Length 52 mm.; diameter varies considerably, greatest diameter 9 mm. Physa: Length 1·5 mm.; diameter 1·5 mm. Larval form: Length 20 mm.; diameter 5–2 mm. Physa introverted.

Locality.—Caught in a fishing-net off Clareville Wharf, Broken Bay, New South Wales, by Professor J. P. Hill, in 1893. Depth of water about four fathoms. Two specimens.

I have the pleasure of naming this, the first known Australian species of *Peachia*, in honour of the discoverer, Professor Hill.

Column-wall.—Sections of the column-wall have a characteristic appearance, owing to the numerous small projections or suckers (Pl. 4. figs. 3, 4, 5) on the surface. These are formed by long processes from the outer border only of the mesoglœa, covered by thin ectoderm, which, however, appears massive between the suckers, where the opposing faces of the ectoderm often

touch. The suckers are fewer and smaller in the contracted physa, which is covered by deeper ectoderm and presents a smoother external surface. The border of the ectoderm is thickly set with long oval nematocysts, lying at right angles to the surface (Pl. 4. fig. 5, *nem.*). These are most numerous in the capitulum and upper scapus, where they form a continuous border touching one another. The large glandular cells recognized by Faurot in *Peachia hastata* (15) are not distinguishable, probably owing to the state of preservation. The ectoderm cells are very long and contain rounded nuclei, internal to which lies the clear, slightly granulated, nervous layer. I have not been able to detect ectodermal muscle in my preparations. The mesoglœa contains many isolated cells, and is laminated throughout the polyp, this lamination being most marked in the column-wall, where the laminæ are so thin as to give the whole structure a fibrous appearance.

The endodermal muscle system is strong and strengthened locally in both capitulum and lower scapus. The plaitings of the mesoglœa, on which the muscle-cells are placed, line the capitulum and scapus throughout, and are present in the greater part of the physa also. These mesoglœal plaitings all contain a darker-staining centre core, surrounded by lighter-coloured supporting substance. In the capitulum and through the greater length of the scapus they are simple and, in longitudinal sections, have the appearance of a band of narrow wavy ribbon running down the column between the mesoglœa and endoderm. In the lower scapus they become branched and finally assume a dendriform appearance, reaching their maximum strength in the scapus adjacent to the physa, where they form long tongues stretching into the cœlenteron. On each side of these tongues are branches, which often divide again, thus largely increasing the surface (Pl. 4. fig. 5). Between these dendriform structures shorter projections are present. This is the strongest part of the body-wall, and it is these muscles, probably, which enable the animal to bore into the sand with its physa and to bury itself up to the capitulum. Holdsworth (3) and Faurot (15) have carefully described this process in the case of *Peachia hastata*, and estimated the time taken in boring at about an hour ; but the endodermal muscles present in the scapus of any species of *Peachia* have not hitherto been described.

The endoderm of the column consists of long narrow cells, which are very easily separated from one another. The endoderm is narrow in the upper part of the polyp, but becomes extremely thick in parts of the physa, as does the ectoderm also. It is, however, probable that the physa is much contracted.

The Sphincter.—The sphincter is represented in *Peachia hilli* by an increase in strength of the endodermal muscle plaitings present in the capitular region. The plaitings remain simple and are still very small, but are nevertheless about twice the length of those present in the upper scapus.

Disc and Tentacles.—The tentacles are short and obtuse, with thin walls

enclosing a very large lumen. A single row of nematocysts of varying sizes is placed on the outer border of the ectoderm, more sparsely than in the column-wall. They are of two kinds, one only of which takes the hæmatoxylin stain. The nucleated zone is very deep, and the clear nervous zone is penetrated by numerous plaitings of the mesoglœa, which carry a strong ectodermal muscle. The mesoglœa and endoderm are thin. The histology of the disc resembles that of the tentacles, but a slight endodermal muscle is also present.

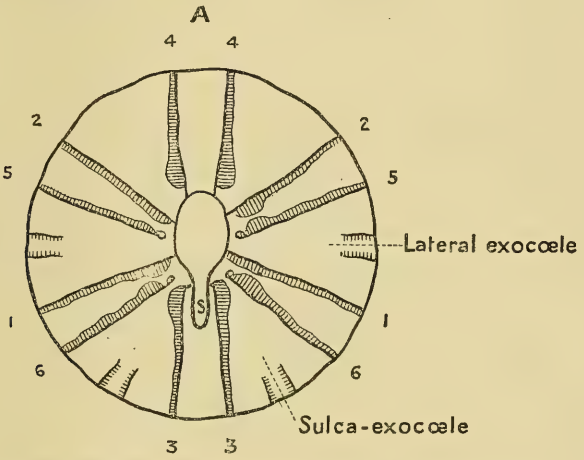
Œsophagus (Pl. 4. figs. 3 & 4).—The most striking feature of the œsophagus is the single enormous siphonoglyphe (Pl. 4. figs. 3 & 4, and text-figure A). This large firm structure extends from the mouth to a point in the body-cavity some distance below the rest of the œsophagus. Its total length in the adult specimen is 1·6 mm., and it terminates 3·7 mm. from the posterior end of the body.

The ventral directives (Pl. 4. figs. 3 & 7, 3 3, and text-figure A, 3 3), by which alone it is supported throughout, remain attached to it below the œsophagus, where it hangs freely in the body-cavity. In fig. 3 a dotted line shows the internal boundary of the siphonoglyphe. In the adult specimen it remains an open tube throughout and its walls enclose a space almost equal in area to the rest of the œsophagus. In the larval form the two endoderm walls are approximated at the entrance to the œsophagus during part of their length, and the siphonoglyphe encloses a relatively smaller area than in the adult.

The ectoderm is deeply folded and of equal thickness in both œsophagus and siphonoglyphe, but becomes thicker in the lower part of the siphonoglyphe. It contains many long gland-cells, especially numerous in the siphonoglyphe, and a row of fine small nematocysts lies in its outer border, while the nucleated layer is very deep. The mesoglœa is finely laminated in the adult; but in the larval form the laminæ are very loose, and show also many light circular patches. The mesoglœa of the œsophagus proper is very thin; that of the siphonoglyphe extremely thick and stiff, but this thickness decreases somewhat in the lower part. The endoderm, which is thicker in the siphonoglyphe than elsewhere, is not sufficiently well-preserved for description.

Mesenteries (Pl. 4. figs. 3, 7, 8, and text-figure A).—There are in the adult form twelve perfect and eight imperfect mesenteries. The latter consist of four very small pairs situated in the lateral and sulcar exocœles (Pl. 4. figs. 3, 7, and text-figure A). Although no gonads are present the cœlenteron on dissection was found almost completely filled with a solid mass formed of the perfect mesenteries. This is markedly the case in the upper sub-œsophageal region, where the digestive endoderm is very thick and divides into several branches each provided with a mesenterial filament. Four pairs of the mesenteries, viz. 1 1, 2 2, 3 3, and 4 4, are attached to

the œsophagus throughout their length (Pl. 4. fig. 3, and text-figure A). The pairs 5 5 and 6 6, probably the last two pairs of mesenteries to be formed (15), are not attached to the lower half of the œsophagus in the adult form. Owing to the capitular region having been cut longitudinally, I have not been able to determine whether or not they are attached to the upper region of the œsophagus. In the larval form the twelve perfect mesenteries only are present. These are fully formed, bearing muscle-pads, digestive endoderm, and mesenterial filaments, and the pairs 5 5 and 6 6 are free throughout their entire course.



Diagrammatic section through lower œsophageal region of *Peachia hilli.*

The longitudinal retractor muscles are unilateral and exceedingly powerful. Distinctly narrower peripherally they widen towards their internal margin and end a short distance from the œsophagus in a large half renal curve (Pl. 4. figs. 3, 8). The long narrow mesoglœal processes on which the muscle-cells are placed frequently branch, and the processes show a central dark-staining core. A number of short thick muscular outgrowths occur on the mesentery between the longitudinal retractor and the œsophagus (Pl. 4. fig. 8, *mu.*).

The parietal muscle, bilateral and well-developed, is situated on short blunt processes of the mesoglœa (Pl. 4. fig. 8, *p.m.*). These on one side extend to a greater width and join the fibres of the longitudinal retractor, on the other in the perfect mesenteries they often form, especially in the œsophageal region, little tufts or brush-like outgrowths. The mesenteries diminish in width towards the posterior end of the column and with them the retractor muscles diminish also. At the posterior end of the scapus they form two groups (Pl. 4. fig. 7). One consists of the pairs 1 1, 2 2, and 3 3, which still retain some digestive endoderm. Of these, 3 3, formerly carriers

of the siphonoglyphe, remain the largest. The pairs 4 4, 5 5, and 6 6 have lost their digestive endoderm entirely and are of about equal size.

The incomplete mesenteries (Pl. 4. fig. 3, *imper.mes.*) have longitudinal retractor muscles on plaitings the same width throughout; their parietal muscle does not form tufts, and they are not provided with digestive endoderm or mesenterial filaments. At the posterior end of the scapus they are already very minute (Pl. 4. fig. 7, *imper.mes.*).

In the larval form there are present twelve tentacles and twelve fully-developed perfect mesenteries, two pairs of which, viz., 5 5 and 6 6, are unattached to the œsophagus. All twelve have muscle-pads, digestive endoderm, and mesenterial filaments. No mesenteries of the second cycle are present.

Physa.—In this region there are a number of pores through the body-wall. There is no external evidence of their presence, and some of the sections being broken, I am unable to give their total number, but have counted over sixty. The physa was cut longitudinally, and I cannot determine whether, as in some species of *Halcampa*, there is a central pore, round which the others are arranged. These pores are placed in longitudinal rows, and are much more numerous in the lower half of the physa than in the upper. Two or three occur on adjacent parts of the scapus. Pl. 4. fig. 6 (1, 2, 3, 4, 5) shows a longitudinal section of the physa-wall with five of these pores cut through in different parts of their course. The mesoglœa between the small suckers of the physa is extremely thin and covered with a thin layer of ectoderm, and at these points the pores are formed. They open into the ectodermal cavities between the suckers (Pl. 4. fig. 6, *po.*), and in this way a free passage is formed to the exterior. The passage formed by the pore itself through the ectodermal layer is, therefore, extremely short.

On the ectodermal side the pores are thickly lined with columnar cells, whose numerous rounded nuclei lie internal to a clear border, containing only an occasional nematocyst (Pl. 4. fig. 6). On the endodermal side the cells are shorter and the nuclei larger. A large increase of endodermal cells is present adjacent to the pores, and through these the passage has been formed to the interior of the body-cavity. The endodermal passage is therefore much longer than the ectodermal.

Gonads.—No gonads were present in the two specimens examined.

Development.—The larval form examined had twelve tentacles and twelve perfect mesenteries. Of these the eight primitive Edwardsian septa were alone complete. The four unattached mesenteries are fully developed and possess muscle-pads and mesenterial filaments. This shows a variation in the development of mesenteries and tentacles as compared with the larval stage of a species of a closely allied species, viz. *Halcampa duodecimcirrata*, described by Carlgren (**14**, p. 42). Carlgren found that larval forms possessing twelve tentacles had all twelve mesenteries attached in the *upper* part of the œsophagus, and were at that stage already in possession of some mesen-

teries, the second cycle. Even younger forms, having only ten tentacles showed the second cycle of mesenteries developing.

Haddon (9) also in describing larval forms of *Halcampa crysanthellum*, which, like those of this larval form, had twelve mesenteries, found that at a stage where the mesenteries 5 5, 6 6, were unattached in the lower œsophagus there were present only eight tentacles. This is the more interesting since Faurot (15) believes Haddon to be mistaken in the classification and considers the larva described to be that of *Peachia hastata*. The fact that the siphonoglyphe figured by Haddon continues below the œsophagus certainly points in that direction.

Our knowledge of the genus *Peachia* is very scanty. The description even of the type species *Peachia hastata* is incomplete and contradictory. It is first mentioned by Reid in 1848 (1) under the name of *Actinia cylindrica*, a name preoccupied. Gosse renamed it *Peachia hastata* in 1855 (2). M'Intosh (10) has described the commensal habits of the larval *Peachia*. From that time its occurrence and external appearance have been noted by various zoologists. Haddon and Dixon (7) summarize the literature to the date of their paper and give an excellent account of the habits and external structures of this anemone. Haddon deduced the existence of pores in *Peachia* from the grooves present externally on the physa of *Peachia hastata* (7), which he considered comparable with the external openings of pores in *Halcampa*. "Mr. Dixon and myself are now satisfied that such (*i. e.* pores) is the true explanation of the appearance we described in *Peachia*" (7 and 8). He included them in his definition of *Peachia*, but has not described them further (11). But Faurot (15, p. 140) some nine years later in describing the movements and actions of living *Peachia hastata* lays emphasis on his opinion that the water with which it fills its body-cavity at this time is ejected entirely by the mouth, by adding "*un orifice à l'extrémité basale n'existe pas.*" That the apparent orifice caused by introversion, and mistaken for a pore by older writers, is not one, is of course certain, but Faurot overlooked the existence of these very numerous pores round the physa of *Peachia hastata*, which, indeed, may serve the very purpose of ejecting water. Still it is to Faurot (15) we owe most of our knowledge of the internal anatomy of *Peachia hastata*. But his excellent paper on the comparative anatomy of several genera of *Actiniæ* does not profess to deal with all their organs. In addition to the above omission, he does not mention the powerful endodermal muscle-system of *Peachia*, denies the existence of a sphincter, and gives an account of several minor structures differing from that given by Haddon.

I have therefore dealt with the anatomy of all the organs of *Peachia hastata* as fully as the condition of my material allowed. I have followed Haddon (11) in describing the bulk of the muscle on the imperfect mesenteries longitudinal retractor. Faurot (15), on the other hand, considers that

the imperfect mesenteries have no longitudinal retractor muscles, that their entire muscle and a corresponding width of muscle on the perfect mesenteries is parietal, and that therefore in the lower part of the scapus in *Peachia hastata* parietal muscle alone is present.

In the size of the perfect mesenteries, in their attachment to the œsophagus, and in their relative width in the subœsophageal region, *Peachia hilli* differs from *Peachia hastata*. In *Peachia hastata* the pair 6 6 alone, the the last pair formed, " deviennent libres dans les deux tiers inférieures de la région œsophagienne " (15). In that species towards the end of the scapus the pair 4 4 does not form a group with 5 5 and 6 6, but has already diminished to the size of the imperfect mesenteries. Faurot photographs (15) show that at a lower level still, roughly corresponding to fig. 7, the pairs 5 5, 6 6 in *Peachia hastata* have also diminished to the same size as 4 4. In *Peachia hilli* these pairs retain their relatively greater width well into the physa.

Professor McMurrich (13) has altered the generic characters as defined by Haddon to include *Peachia koreni*. Although, on account of his unwillingness to mutilate his only specimen, he has not been able to describe the species in detail, there is no doubt that it is a totally distinct species from *Peachia hilli*. In *Peachia koreni* the conchula is as large as the tentacles, of which there are only eight, though all six pairs of perfect and four pairs of imperfect mesenteries are present. There is also in the American form no distinction into capitulum, scapus, and physa. This example of *Peachia koreni* may be a young form, but, if so, its tentacles and mesenteries are developing in reverse order to those of the larval form of *Peachia hilli*.

Peachia hilli is the second species of this genus recorded from the Pacific. The first, *Peachia carnea* (6), found on the beach, Dunedin, New Zealand, differs from *Peachia hilli* in being flesh-coloured. Only the external characteristics of this anemone have been given by Hutton, and since these apply equally well to the genus *Halcampa* as to *Peachia*, its position is quite uncertain. Another form from the Southern Hemisphere, *Peachia antarctica* (South Georgia), was classed as a *Peachia* by Pfeffer on its external characters only, in his " Zur Fauna von Süd-Georgien," Jahr. Hamb. Anstalt, vi. Jahrg. 1888. In 1898 Carlgren found that this was in reality a *Scytophorus* and renamed it *Scytophorus antarcticus* (23).

Phellia browni. (Pl. 5. figs. 9–13.)

Form (Pl. 5. figs. 9 & 9 *a*).—Single, conical, fixed; scapus and almost the whole of the capitulum thickly covered with large yellow, brown, and white grains of calcareous sand; beneath these lies a thick coating of transparent siliceous grains. This sand forces itself irregularly into the column-wall, but does not penetrate the surface, so that the indentations in which it lies are completely lined by ectoderm coated by mucus. The grains are best

removed by careful scraping under a dissecting microscope, but this operation needs care, as small fragments are deeply embedded. Their removal leaves exposed a roughened deeply pitted surface of spongy appearance (Pl. 5. fig. 10), and discloses at point of closure of the capitulum six deep longitudinal ridges (Pl. 5. fig. 9), which continue distally down fully two-thirds of the inverted portion. Where the ridges cease, a circular groove with deep folds in its surface (Pl. 5. fig. 10, *c.g.*) runs round the capitulum. Immediately below this spring out a large number of thin, naked, nose-like projections, which completely close the entrance to the oral disc, when, as here, the capitulum is inverted (Pl. 5. fig. 10). These thin nose-like projections are entirely free from both sand and mucus. The pedal disc does not extend beyond the general body of the polyp, which reaches its greatest width in the pedal region. The tentacles, short, blunt, and marginal, are transversely grooved and number over 40 (Pl. 5. fig. 10). They are placed in several cycles which are difficult to distinguish. Those in the innermost cycle are the longest, and measure 2·5 mm.; the shortest measure ·5 mm.

Colour.—Professor Hill states that the anemone was sand-coloured in life. In spirit it is unchanged.

Dimensions.—Somewhat irregular in shape; narrower distally. Greatest height 11·5 mm.; greatest diameter 9 mm.; diameter at capitulum 4·5 mm. (Pl. 5. fig. 9 *a*).

Locality.—Collected by Professor Hill in 1894, on the Pacific Ocean beach opposite Creel Bay, Broken Bay, New South Wales.

I wish to associate with this species the name of Mr. E. T. Browne, the well-known authority on medusæ, to whom I am indebted for kindly assistance.

Column-wall (Pl. 5. figs. 10 & 13).—The surface of the polyp is deeply indented and covered below the sand-grains with a yellow mucous layer in which numerous small foreign particles are embedded. I have not been able to fully determine the presence of a cuticle, but the ectoderm is badly preserved and has been much torn in scraping off the sand. The ectoderm of the capitulum contains numerous nematocysts present everywhere, but occurring most abundantly in the soft nose-like projections. The mesoglœa is thick, finely fibrous, almost homogeneous, and doubles its width in the capitular region. It contains numerous isolated cells and small lacunæ. The endoderm is deep and deeply folded, especially in the capitulum. Endodermal muscle on long plaitings of the mesoglœa lines the cœlenteron throughout; these muscle-plaitings are still further developed and become slightly branched in the region of the proximal part of the sphincter (Pl. 5. fig. 10, *end.m.*).

Sphincter (Pl. 5. figs. 10 & 11).—The sphincter muscle, large, powerful, and mesoglœal, is peculiar in form. It recalls the double sphincter of

Zoanthus, but here the two portions are connected. The proximal portion is much the longer, of compact form, of almost uniform width, and much nearer the endoderm than the ectoderm. The second, or distal, expansion occurs in the soft nose-like projections of the capitulum. These projections vary in shape, and this portion of the sphincter varies with them, since it occupies the whole width of the mesoglœa here present, and runs into all but the finest branches of the projections. The narrow strip connecting the distal and proximal part of the sphincter lies in the circular depression round the capitulum (Pl. **5**. fig. 10). The muscle-cavities are closely pressed together, polygonal in shape, and only broken by narrow irregular strands of mesoglœa passing transversely (Pl. **5**. fig. 11). In transverse sections the sphincter shows a straight line on the endodermal, while on the ectodermal side a large wave enters the base of each ridge of the capitulum.

Tentacles (Pl. **5**. figs. 10 & 12).—The tentacles are thick-walled, containing a small lumen. The annular grooves on their surface involve the ectodermal layer alone, which is very thick and has in its external border a closely packed row of nematocysts placed at right angles to the surface (Pl. **5**. fig. 12). The strong ectodermal muscle is placed on long branched mesoglœal processes which end in the nervous zone of the ectoderm. Since they are not enclosed by mesoglœa on the ectodermal side, and the branches do not anastomose, the fibres are not mesoglœal in position (Pl. **6**. fig. 12). The mesoglœa is narrow and homogeneous, supporting a slight endodermal muscle. The endoderm is deep and deeply folded.

Disc.—The histology of the disc closely resembles that of the tentacle. The ectoderm is deep with an outer border of nematocysts, and the strong ectodermal muscle is placed on long branched mesoglœal processes, which end in the nerve zone of the ectoderm. These mesoglœal processes branch, but do not anastomose with one another, and therefore the muscle remains ectodermal in position. This muscle becomes deeper towards the point of junction of the perfect septa. The ectoderm of the disc is much narrower than that of the tentacles.

Œsophagus (Pl. **5**. fig. 13).—The polyp was cut through the œsophageal region transversely, the cut surface of the lower half being represented in the figure. Twelve deep longitudinal grooves are present. Of these, the two grooves which occupy the normal position of siphonoglyphes, *i. e.* which lie between the points of attachment of the two ventral and the two dorsal directives respectively, are not much deeper than the other ten, but the specimen is greatly contracted. There are also present, probably owing to contraction, a number of very deep transverse grooves. The tissues are not well enough preserved for histological purposes. The ectoderm, which is deep, contains numerous gland-cells. The mesoglœa, fibrous and thin in the long grooves, widens immensely in the lobes between the longitudinal grooves, and these contain numerous enclosed cells. The endoderm is narrow.

Mesenteries and Acontia (Pl. 5. fig. 13, *mes.*, *a.*).—There are three cycles of mesenteries; the formula for each sextant being PuIIuP. The mesenteries of the first cycle number six pairs, including two pairs of directives (Pl. 5. fig. 13, *me.*[1]). They alone are perfect and carry the gonads; there are also six pairs of imperfect mesenteries of the second (Pl. 5. fig. 13, *me.*[2]) and twelve pairs of the third cycle (Pl. 5. fig. 13, *me.*[3]), all of which are in a very rudimentary state. There is no trace of a fourth incomplete cycle present in several of the species already described, and the suggestion, therefore, of Kweitniewski (21) that the partial development of the fourth cycle might be a generic character is incorrect. This fourth cycle is absent also in *P. vermiformis*.

Perfect Mesenteries.—The longitudinal retractor muscle of the perfect mesenteries is contained in a muscle-pad which is large and reniform in cross-sections. The distal end and external appearance of this muscle-pad is shown in fig. 10, *m.p.*, Pl. 5. It continues proximally to within a short distance of the pedal disc. The muscle-cells are situated on slight, long, very numerous and richly-branched processes (Pl. 5. fig. 13, *l.r.m.*). Distally, beyond the level of this muscle-pad, short blunt muscular processes occupy the greater width of the perfect mesenteries. Here the mesoglœa is thicker and contains isolated cells. The perfect mesenteries are also supplied with a strong parieto-basilar muscle on plaitings of the mesoglœa. This is produced on one side into a long brush-like tuft (Pl. 5. fig. 13, *p.h.m.*). The mesenterial filaments of the perfect mesenteries are divided into several branches. A septa is apparently present in the perfect mesenteries, but owing to tears caused by removal of sand and to imperfect preservation this point could not be decided.

Incomplete Mesenteries (Pl. 5. fig. 13, *me.*[2], *me.*[3]).—The incomplete mesenteries of the second and third cycles are rudimentary, without gonads, mesenterial filaments, or muscle-pads. They possess strong blunt muscle processes slightly branched on side. The mesenteries of the second cycle are only slightly wider than those of the third. In the region of the pedal disc, where the perfect mesenteries are narrower and have lost their muscle-pads, the internal borders of all three cycles become connected together in groups. The largest group consists of 16 mesenteries, whose inner border forms part of a circle lined by muscle processes. Examples of somewhat similar coalescences of several mesenteries of different cycles have already been recorded by Dixon (12) and by Parker (19).

The *Acontia* (Pl. 5. figs. 10, *a.*, 13, *a.*) are very large and are visible immediately on opening the cœlenteron. They form very white coiled tubes of considerable length, some of which pass well into the capitulum (Pl. 5. fig. 10, *a.*). Transverse sections show that they are rounded and one side is fully armed with nematocysts, but the histology is not well preserved. No cinclides are visible.

Gonads (Pl. **5**. fig. 13, *gs.*).—The specimen was a female. The gonads, which were carried by the six pairs of perfect mesenteries, almost filled the cœlenteron. Transversely they extended from the œsophagus to the body-wall, passing into the spaces between the imperfect mesenteries, longitudinally, from the level of the mouth to a little above the pedal disc. The immense number of ova present were in different stages of growth.

Phellia capitata. (Pls. **5**, **6**. figs. 14–19.)

Form (Pl. **5**. fig. 14).—Single, fixed; capitulum slightly swollen; base much broader, there being a gradual increase from the centre of the column to the pedal disc, which expands broadly beyond the column-wall; surface of the scapus irregularly pitted and gritty with fine sand; on the capitulum the sand very sparse and the irregularities of the surface arranged in deep transverse grooves; the greater part of the capitulum and the scapus beneath the sand-grains covered with thick yellow mucus, in which small objects are embedded; the small distal portion of the capitulum delicate, free from mucus and sand, quite smooth and light sand-coloured. In the specimen examined this portion pressed outwards forms a ridge protruding round the anterior end of the polyp between the transverse grooves of the lower capitulum and the expanded tentacles (Pl. **6**. figs. 15, 16, 19, *d.cap.*). Tentacles (Pl. **5**. fig. 14, Pl. **6**. figs. 15, 16) short, slightly annulated, in two cycles, the inner the larger; 39 present, and a space about equal to one-eighth the circumference of the disc, which is devoid of tentacles, has several minute buds at long intervals. The œsophagus is extruded together with masses of the gonads (Pl. **5**. fig. 14, *œs.*, *gs.*); owing to the attachment of the perfect mesenteries to the inner wall of the œsophagus this organ is slightly lobed in extension; its lower border is deeply grooved transversely. There is no indication of a siphonoglyphe.

Colour.—Brown in spirit, owing to minute dark brown pigment spots which cover the surface to the edge of the light-coloured naked distal parts of capitulum.

Dimensions.—Height 13 mm.; average diameter 5 mm., diameter at pedal disc 9 mm.

Locality.—Collected by Professor Hill in 1894; on the Pacific Ocean beach opposite Creel Bay, Broken Bay, New South Wales.

This species is named *Phellia capitata* on account of the peculiar swollen heads of the longitudinal retractor muscles of the mesenteries.

Column-wall (Pl. **6**. figs. 15, 17).—The column-wall, narrow below, owes its greater width distally to the inclusion of a wide mesoglœal sphincter (Pl. **6**. fig. 15, *sph.*). Its surface is very irregular, but the sand-grains with which it is covered do not penetrate into the deeper indentations. They adhere chiefly to the surface of the yellow abundant mucus, and are

therefore more easily removed than in *Phellia browni*, and the underlying structures are less destroyed in the process. Both mucus and a cuticle cover the surface of the ectoderm of the column and lower capitulum, and the ectoderm underlying these structures is narrow and badly preserved. In the naked distal portion of the capitulum the ectoderm is much wider (Pl. 6. fig. 15, *d.cap.*), consisting of very deep columnar cells, and nematocysts, which are not numerous, appear to be confined to this portion.

Small ill-defined bodies, probably badly preserved isolated cells, are scattered irregularly through the mesoglœa and occur in the sphincter also, where they are easily detected, being of much larger size and staining deeper with carmine than the muscle-cells of the sphincter itself. An endodermal muscle lining the cœlenteron is present on unbranched mesoglœal plaitings, which do not appear to be further developed in the capitular region (Pl. 6. fig. 15, *end.m.*). The endoderm forms deep triangular ridges between the mesenteries (Pl. 6. fig. 17, *end.*).

Sphincter.—The sphincter, large and mesoglœal, lies throughout its course nearer the endoderm than the ectoderm (Pl. 6. fig. 15, *sph.*). Less powerful than in *Phellia browni*, it has the same double form as in that species, lying chiefly in the lower capitulum, with a second marked expansion in the naked distal portion where it occupies the full width of the mesoglœa. The muscle-cavities are very numerous, small, oval or round, lined with muscle-cells and embedded in an irregular manner in the mesoglœa. These cavities lie singly and retain their own shape, but there are very few scattered cells, and the shape of the sphincter as a whole is compact. The naked portion of the capitulum and the distal expansion of the sphincter which it contains are more or less constant in shape in this specimen, thus forming a great contrast to the long prolongations of both capitula of the sphincter which are present in the last species, *Phellia browni*. This difference is probably not specific, but the result of *Phellia capitata* being in full expansion, while *Phellia browni* is in a contracted state. See Verrill (4) on the sphincter of *Phellia panamensis*, later named *Phelliopsis panamensis* (22). The ectodermal side of the sphincter is irregularly waved, and it reaches its greatest width at about the centre of its length.

Tentacles (Pl. 6. figs. 15, 16).—The tentacles are thick-walled with a small lumen. The ectoderm, the broadest of the three layers, is well supplied with nematocysts and has a broad nervous zone. The ectodermal muscle is powerfully developed on branched processes of the mesoglœa, which end in the nervous zone of the ectoderm, as in the last species, and are therefore not mesoglœal in position. Short and almost unbranched on the outer side of the tentacle, these mesoglœal processes are at least twice as broad on the inner side which faces the oral aperture (Pl. 6. figs. 15, 19, *ect.m.*^{1}, *ect.m.*^{2}). The mesoglœa, which is narrow, bears on its internal border a well-marked ectodermal muscle. The endoderm is deeply folded.

Disc (Pl. 6. fig. 19, *d.*).—The musculature of the disc and tentacles in the former species alike, are in this species very different. The ectodermal muscle of the disc is only slightly developed and strongly resembles that of *Phellia sollasi* (20), another Australian species. A few mesoglœal processes are present peripherally. More centrally these processes are absent and the muscle very feebly developed. The endoderm is narrower than in the tentacles and very few nematocysts are present in the ectoderms.

Mesenteries and Acontia (Pl. 6. fig. 17).—There are three cycles of mesenteries, the formula for each sextant being the same as in the last species, viz. PuIIuP. The perfect mesenteries are of the first cycle only, number six pairs including the directives, and carry the gonads ; there are also six pairs of imperfect mesenteries of the second and twelve pairs of imperfect of the third cycle.

Perfect mesenteries. A surface view of the distal part of a perfect mesentery, as it appears on opening the anterior end of the polyp longitudinally, is shown in Pl. 6. fig. 16. It will be seen that the longitudinal retractor muscle has a most unusual form. Throughout the greater length of the mesentery it consists of a muscle-pad of uniform and very narrow width (Pl. 6. fig. 16, *m.p.*), but at its distal extremity it increases suddenly in size and ends in a large bulb or head (Pl. 6. fig. 16, *m.b.*). The œsophagus, which is attached to the perfect mesenteries and does not extend below the level of the enlarged heads, has, in eversion, drawn the mesenteries upwards and outwards. The position of the heads of the muscle-pads in the lobes of the everted œsophagus is due to this fact, and their curvature probably arises from the same cause.

The internal structure of the muscle-pad and its enlarged head are shown and compared in Pl. 6. figs. 17, 18, & 19. In longitudinal and transverse sections of the head (figs. 18, 19) it will be seen that the structure consists entirely of very numerous delicate processes branching from a mesoglœal core, the muscle-cells being situated on these processes. The muscle-pad shown in transverse section (fig. 17, *m.p.*) is drawn on the same scale as the muscle-head in fig. 18. In structure the muscle-pad differs from the muscle-head only in the fact that the mesoglœal core is much slighter in the pad and does not penetrate so deeply. In shape also the transverse section of the pad is more reniform than that of the head.

The marked difference in the form of the retractor muscle in this species and in *Phellia browni* may be seen by comparing fig. 10 on Plate 5 with fig. 16 on Plate 6.

The mesenterial filament is very small ; immediately below the œsophagus it is divided into three parts ; lower down it is single (Pl. 6. fig. 17, *me.*[3]).

The parieto-basilar muscle, which is present in the perfect mesenteries only, forms a well-developed brush-like tuft on that side of the mesentery

which is opposite to the longitudinal retractor muscle. It has a depth equal to that of the third cycle of mesenteries (Pl. 6. fig. 17, *p.m.*).

The incomplete mesenteries (Pl. 6. fig. 17, *me.*^{2}, *me.*^{3}) of the second and third cycles are very rudimentary and closely resemble the corresponding mesenteries in *Phellia browni*. Their feathery appearance in both cases is due to muscle processes of the mesoglœa on each side. They are devoid of gonads and muscle-pads. Owing to imperfect preservation I am unable to decide whether a slight mesenterial filament is present on the mesenteries of the second cycle or not, but the mesenteries themselves are quite rudimentary and scarcely longer than those of the third cycle. The perfect and imperfect mesenteries of *Phellia capitata*, unlike those of *Phellia browni*, do not approximate in width towards the pedal disc or become connected with one another. The complete mesenteries in the proximal end of the body meet in the centre of the pedal disc, to which their basal extremities are attached. The incomplete mesenteries are also attached to the pedal disc, but they are narrower and end at varying distances from its centre. The pedal disc, therefore, has a great number of radial lines at its circumference, twelve of which, representing the attachment to the perfect mesenteries, meet in the centre.

The Acontia (Pl. 6. fig. 17, *a.*).—The acontia are numerous, thick, and long, but not so dead white as in the former species, and therefore not so prominent at first sight. Transverse sections (Pl. 6. fig. 17, *a.*) show a round figure with a groove on one side. The opposite or convex side is strongly armed with nematocysts, and there is an axis of connective tissue. In form, therefore, the acontia of both *Phellia browni* and *capitata* closely resemble the acontia described by Hertwig (5) in *Cercus spinosus* and *Calliœtis parasitica*, and are unlike those figured by Carlgren for *Sagartia viduata*, *Sagartia undata*, *Metridium dianthus*, and *Chondractinia* (14). Unfortunately the muscle-fibres, which Hertwig says "lie on the convex side of the mesoglœa, where the nematocysts lie," and which Carlgren finds in every acontium examined by him "auf der den Nesselzellen entgegengesetzten Seite," are here not well enough preserved to distinguish.

Gonads (Pls. 5, 6. figs. 14, 16, *gs.*).—The specimen was a male and the gonads, carried by the perfect mesenteries only, were extremely well developed and formed large bunches, partly extruded with the œsophagus; they also almost filled the cœlenteron distally, but diminished in size proximally. In the specimen examined it appeared that the perfect mesenteries ceased to bear gonads at different levels, but the state of preservation is not good enough to determine the point. The spermatozoa present are not fully ripe.

These two Australian species are characterized by the unusual strength of the sphincter and its peculiar contraction into two parts, which does not occur in other known species of the genus. The size and prominence of the

acontia are also unusual characteristics. Haddon and Knietniewski, indeed, consider smallness of the acontia a generic character (21). *Phellia browni* (and in less degree *Phellia capitata*) is distinguished also by the thickness of its sand-incrustation.

The known species of *Phellia* from the Pacific—viz., *Phellia vermiformis* (17) from Torres Straits and *Phellia sollasi* (18 and 20) from Funafuti, *Phellia ternatana* (16) from Ternati, and *amboniensis* (21) from Ambon—differ widely from those here described in the three characters named above. Other points of difference are the external shape and the form of the longitudinal retractors, and the mesenteric formula of *Phellia sollasi*, *ternatana*, and *amboniensis*. Haddon's collection included two other anemones from Torres Straits, which he had "no doubt were *Phellia*." They were, however, lost before examination, and their external characteristics alone are given. These do not agree with those of *Phellia browni* and *capitata*. Until rediscovered, their position is in reality doubtful, since the external characters of *Phellia* and *Chondractinia* are alike, the fact that *Phellia* bear the gonads on the perfect mesenteries being the point of difference between the two genera.

An interesting series of stages of development of the ectodermal muscle of the disc is shown in the genus *Phellia*. In *Phellia sollasi* and *Phellia capitata* we find it at its lowest stage. A few fibres, stronger near the capitulum, are all that are present. In *Phellia browni* these fibres are large and branched and present over the whole disc, while in *Phellia ternatana* anastomosing of the branches has taken place to some extent, and the ectodermal muscle is now partly mesoglœal in position. This process is carried still further in *Phellia amboniensis*. Whole bundles of muscle-fibres are here enclosed by the anastomosing of the mesoglœal branches, which are 3–4 times as wide as the mesoglœa itself, but as yet very few of these fibres have sunk into the mesoglœa. A step further in the development would give ectodermal muscle of the disc as mesoglœal in position as that of a mesoglœal sphincter which originates from endodermal muscle.

Although the partial division of the sphincter into two parts seems to be peculiar to *Phellia browni* and *capitata*, the fact that it enlarges at its narrower distal end to fill the whole of the mesoglœa has been noticed by other observers, viz. Knietniewski (16) and McGuire (20). May this not be generic?

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Lettering.

a. Acontium.
c. Cuticle.
c.g. Circular groove of capitulum.
d.cap. Distal portion of capitulum.
d.sph. Distal portion of sphincter muscle.
ect. Ectoderm.
ect.m. Ectoderm muscle.
end. Endoderm.
end.m. Endoderm muscle.
gr. Groove.
gs. Gonads.
imper.mes. Imperfect mesentery.
m. Mesoglœa.
*m.*1, *m.* 2. Different lengths of ectodermal muscle in tentacles.
m.b. Bulb or head of long retractor muscle of mesentery.
mes. Mesentery.
me.^{1}, *me.*^{2}, *me.*^{3}. Mesenteries of 1st, 2nd, and 3rd cycle.
m.f. Mesenteric filament.
m.p. Muscle-pad of long retractor muscle of mesentery.
mu. Muscle.
muc. Mucus.
nem. Nematocysts.
œs. Œsophagus.
p. Physa.
p.b.m. Parieto-basilar muscle.
p.m. Parieto muscle.
po. Pore.
s. Scapus.
sd. Grains of sand.
si. Siphonoglyphe.
sph. Sphincter.
su. Sucker.
tent. tentacle.

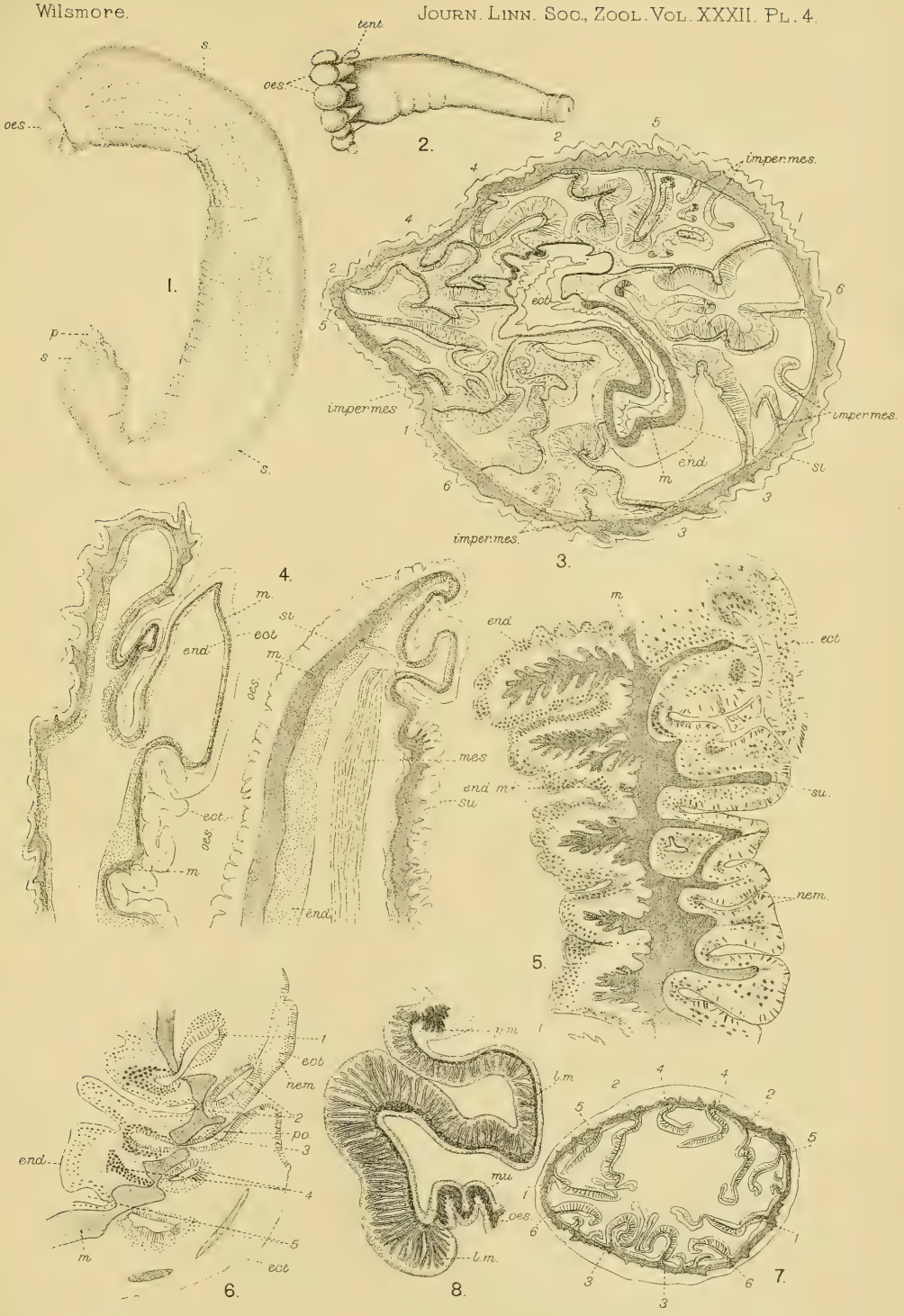
EXPLANATION OF THE PLATES.

Plate 4.

Fig. 1. *Peachia hilli.* × 2.
2. *Peachia hilli.* Larval form. × 2.
3. *Peachia hilli.* Transverse section through œsophageal region. × 12.
4. *Peachia hilli.* Longitudinal section through capitular region. × 14.
This section passes through the œsophagus and shows the thick wall of the siphonoglyphe on the right-hand side.
5. *Peachia hilli.* Longitudinal section through the lower end of the scapus, showing strong development of endodermal muscle. × 68.
6. *Peachia hilli.* Longitudinal section through part of physa, showing five pores. × 188.
7. *Peachia hilli.* Transverse section through lower scapus near physa. × 12.
8. *Peachia hilli.* Perfect mesentery. × 52.

Plate 5.

Fig. 9. *Phellia browni.* End view. × 3.
9*a*. *Phellia browni.* Side view. × 3.
10. *Phellia browni.* Longitudinal hand-cut section through capitular region. The sand-grains are removed from the lower half, leaving the rough deeply pitted surface exposed. Drawn under dissecting microscope.
11. *Phellia browni.* Longitudinal section through sphincter. × 188.
In upper part the endodermal muscle is figured attached to a mesentery, in the lower part it is represented lined by the endoderm of the column-wall.



L. J. Wilsmore, del.

NEW HEXACTINÆ.

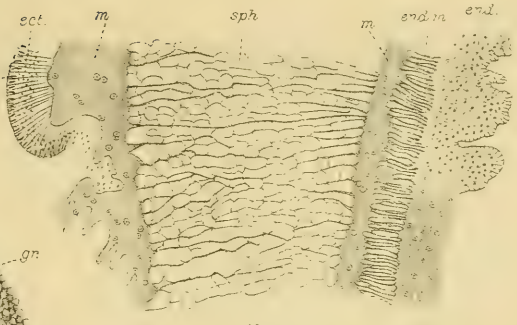
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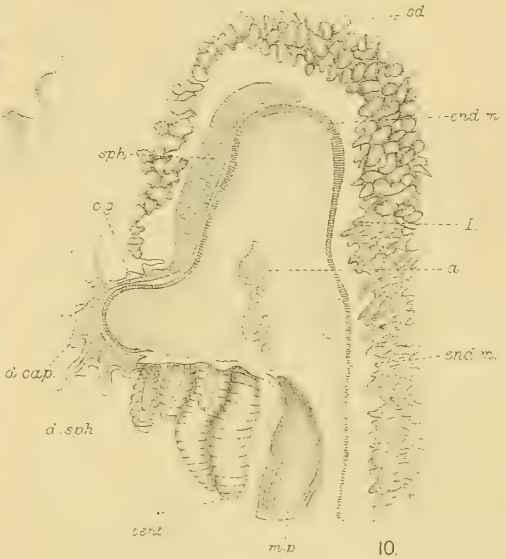
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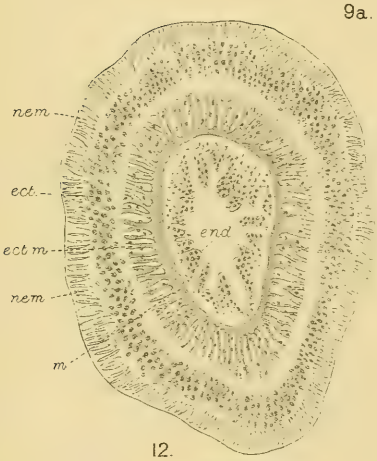
9a.



11.



10.



12.

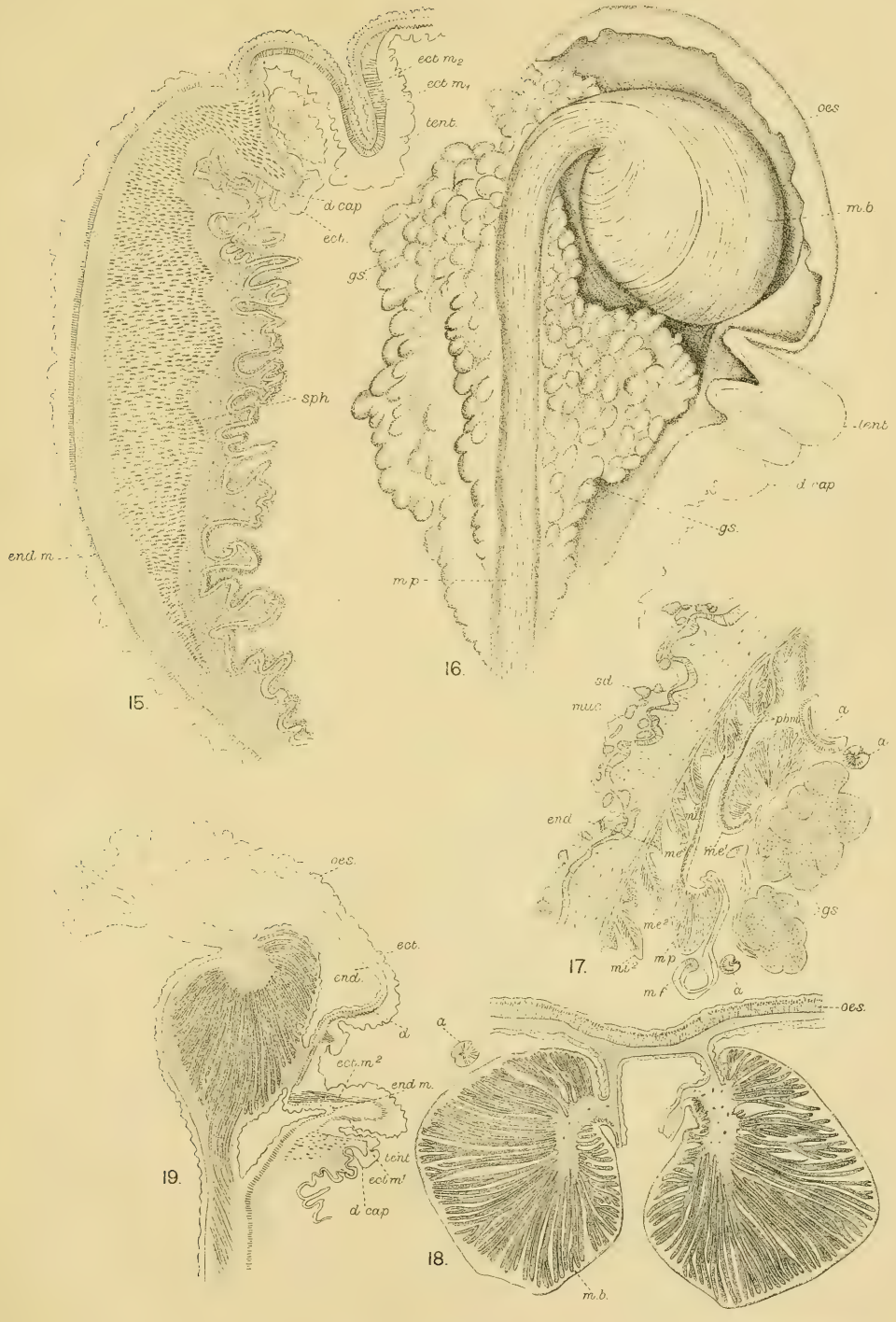


14.



13.

L.J.Wilsmore, del. NEW HEXACTINÆ. E.Wilson, Cambridge



L. J. Wilsmore, del. E. Wilson, Cambridge.

NEW HEXACTINÆ.

Fig. 12. *Phellia browni.* Transverse section through a tentacle. × 282.
Shows large development of ectodermal muscle.

13. *Phellia browni.* The polyp was cut in two transversely through the œsophageal region. This figure represents the lower half viewed as a solid object. Drawn under a dissecting microscope. × 12.

14. *Phellia capitata.* × 3.

Plate 6.

Fig. 15. *Phellia capitata.* Longitudinal section through sphincter and tentacles. × 44.

16. *Phellia capitata.* Longitudinal retractor muscle *in situ.* The everted œsophagus has been cut open longitudinally, and the gonads and muscles are exposed to view. Drawn under a dissecting microscope.

17. *Phellia capitata.* Transverse section showing examples of the three cycles of mesenteries. × 52.

18. *Phellia capitata.* Transverse section through enlarged heads of two longitudinal retractor muscles. × 52.

19. *Phellia capitata.* Longitudinal section through œsophagus, disc tentacles, and muscle-head of retractor muscle. × 34.

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OF

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The British Museum Collection of Blattidæ enclosed in Amber.

By R. Shelford, M.A., F.L.S.

(Plate 7.)

[Read 4th May, 1911.]

In a previous number of this Journal (Zool. vol. xxx. 1910, pp. 336–355) I described a large collection of Blattidæ in amber belonging to the late Dr. R. Klebs, of Königsberg-i.-Pr. The memoir here presented deals with a smaller collection which Dr. A. Smith Woodward, F.R.S., has most kindly handed over to me for examination and study. The specimens come from several localities and from at least two geological horizons, and by my study of them I am enabled to extend slightly our knowledge of the cockroaches of the past. The extreme modernity of the species is as apparent in this collection as in that belonging to Dr. Klebs, and again I find it unnecessary to erect a single new genus for the new forms which I describe. For this I was prepared, but I was certainly not prepared to find an example of the modern species *Euthyrrhapha pacifica*, Coq., in the British Museum collection; and yet such is indeed the case. This species, which at present is found in most of the tropical regions of the world, occurred in Miocene times in Europe, as evidenced by a well-preserved specimen in amber which, after a careful examination, I find to be identical with modern pinned specimens in the Hope Museum, Oxford. If *Euthyrrhapha pacifica* was a generalised type of cockroach, its occurrence in the Miocene period would perhaps excite but little surprise; but it is a highly modified form and the type of wing-structure is quite peculiar.

The wide geographical distribution of this species is sufficient evidence of its "fitness" to survive amidst divergent conditions of life. Its occurrence in Europe in Miocene times, and in a form which, so far as can be seen, does not differ in any important particular from examples extant to-day in South Africa, shows that the survival-value of the species is no new attribute, but a heritage from a past of very respectable antiquity. Until our knowledge of the Tertiary Blattidæ is much more complete than it is at present, it will be impossible to say whether the present distribution of *E. pacifica* is an extension of a more restricted range in Miocene times, or if the species had a wider distribution then than at present.

The collection under notice may be classified as follows :—

I. Oligocene species from	
a. East Prussia	2 specimens.
b. Samland	12 specimens.
II. Miocene species from Stettin	7 specimens.
III. Species from Africa, geological horizon unknown.	9 specimens *.

I have throughout this paper, in order to facilitate reference, quoted the numbers which the individual specimens bear.

I. OLIGOCENE SPECIES.

Dr. Klebs's collection must be nearly complete and exhaustive of the Baltic provinces, for not a single British Museum specimen from this region and horizon can be referred to a new species.

a. East Prussia.

Ischnoptera gedanensis, *Germ. & Ber.*

Blatta gedanensis, Germar & Berendt, Organ. Reste in Bernstein, Bd. ii. Abt. 1, p. 33, pl. 4. fig. 4 (1856).

One male, No. I 13762.

Phyllodromia ? furcifera, *Shelf.*

Phyllodromia furcifera, Shelford, Journ. Linn. Soc., Zool. xxx. (1910) p. 346.

One female in a state of such poor preservation that identification is very doubtful. No. I 13763.

b. Samland.

Nearly all of these specimens are larvæ, which it is impossible to refer with any degree of certainty to species described from adult forms. Even when the entomologist is dealing with modern species the allocation of larvæ to their adult forms is attended with great difficulty, unless he is aided by careful field-observations and accurate data ; it will be readily understood that the difficulty is enormously increased when the material in the entomologist's hands is fossil. Very young larvæ were easily trapped in the resin which flowed from the trees in the Baltic Oligocene forests, but large, powerful adults could free themselves and leave no trace behind. The

* One of the specimens sent to me is a larval Locustid; this, of course, is not included in the above list.

student of the amber fauna is therefore always conscious that he has before him only the weaker and more fragile forms, which could not escape their living grave.

ECTOBIUS BALTICUS, *Germ. & Ber.*

Blatta baltica, Germar & Berendt, Organ. Reste in Bernstein, Bd. ii. Abt. 1, p. 34, pl. 4. fig. 5 (1856).

One male, quite typical in appearance. No. I 13755.

ISCHNOPTERA sp.

A mere fragment of the entire insect, consisting of head, pronotum, and front legs only. No. I 13746.

TEMNOPTERYX KLEBSI, *Shelf.* (Plate 7. figs. 3, 4.)

Temnopteryx klebsi, Shelford, Journ. Linn. Soc., Zool. xxx. (1910) p. 349.

One male, No. I 13756.

I am able to supplement my original description of this species, as the British Museum specimen is in better condition than the type:—Sixth abdominal tergite with the posterior margin sinuate. Seventh to ninth abdominal segments constricted. Subgenital lamina subquadrately produced, with two styles asymmetrically placed, the right situated at the bottom of a deep notch, the left on the margin. Titillator penis extruded, sharply pointed, apex not hooked.

? NYCTIBORA SUCCINICA, *Shelf.*

Nyctibora succinica, Shelford, t. c. p. 350.

To this species I refer with very considerable doubt a larva (No. I 13748), a larval moult (No. I 13754), and a solitary hind-leg (No. I 13757). The larva is considerably smaller than the type, itself described from a larva, and the moult is smaller still. The shortness of the tarsi with their well-developed pulvilli and arolia show that these specimens cannot be referred to any Phyllodromiine genus, nor to any Periplanetine genus known to occur in the amber fauna. Consequently there is a distinct balance of probability in favour of these specimens being young larvæ of *Nyctibora succinica*, but I fear that my determination of the species can go no further than that. The single hind-leg is not devoid of interest, since it reveals one of the means whereby the remnants of the amber fauna have been preserved. The tarsal claws are entangled in some strands of spider (?) silk; the anterior edge of the femur is ruptured and some torn muscles protrude from the rupture, showing that the leg was forcibly torn from the body probably by the insect's own frantic struggles to free itself. The amber surrounding the

derelict leg is quite clear and undisturbed, so that the enclosure of the leg in resin was an event ensuing after its entanglement.

? POLYPHAGA FOSSILIS.

Polyphaga fossilis, Shelford, Journ. Linn. Soc., Zool. xxx. (1910) p. 351, pl. 48. fig. 21.

One very young larva which can only be identified with great uncertainty. The preservation of the specimen is not good. No. I 13752.

LARVÆ.

Four specimens, Nos. I 13747, I 13749, I 13750, I 13753, are probably the very young larvæ of a species of *Phyllodromia* : a fifth example, No. I 13751, is a young larva of one of the Blattæ muticæ ; the insect is much distorted owing to the extrusion of some of the viscera between the thoracic sclerites ; it is possibly identical with the *Polyzosteria parvula* of Berendt (Ann. Soc. ent. France, vol. v. p. 542, pl. 16. fig. 1, 1836).

II. MIOCENE SPECIES FROM STETTIN.

The small number of Miocene specimens debars us from drawing any very valuable conclusions from a comparison of the Oligocene and Miocene Blattidæ in amber, but we may note the following points :—

The genera *Ectobius*, *Ischnoptera*, *Temnopteryx*, *Nyctibora*, *Holocompsa*, and *Polyphaga* are not represented in the collection from Stettin; two genera make their first appearance in the Miocene, *Pseudophyllodromia* and *Euthyrrhapha* ; two genera, *Phyllodromia* and *Ceratinoptera*, are common to both horizons, but the Miocene species of the former genus are very different from the Oligocene species and present, if possible, even a more modern appearance. Comment has already been passed on the occurrence of the genus *Euthyrrhapha* in the Miocene fauna.

These British Museum specimens have the surface of the amber blocks reticulated with minute cracks, so that the examination of the enclosed insects is attended with some difficulty, but I hope that I have succeeded in making out all the details of structure which are visible.

PHYLLODROMIA WOODWARDI, sp. n. (Plate 7. fig. 5.)

One male, No. 58577 ; one female, No. I 13770.

Flavo-testaceous ; eyes rufous ; frons with a V-shaped dark macula. Antennæ long and slender, apical joints dark. Pronotum transversely elliptical, anteriorly not covering vertex of head, posteriorly very slightly produced, disc immaculate, lateral margins hyaline. Tegmina and wings barely exceeding apex of abdomen. Tegmina immaculate, moderately broad, the discoidal sectors straight. Wings with mediastinal vein multiramose

costals few and ramose, ulnar vein ramose. Abdomen beneath immaculate ; subgenital lamina (♂) symmetrical, posteriorly produced into a small quadrate lobe, the styles being situated in small notches on either side of the lobe, (♀) semi-orbicular, ample ; supra-anal lamina (♀) projecting slightly beyond the subgenital lamina, its apex triangularly emarginate. Cerci moderately long, banded beneath with fuscous, 11-jointed. Front femora with the anterior margin beneath armed with a complete row of spines, the more distal shorter than the others ; remaining femora moderately armed.

Total length (♂) 12 mm., (♀) 15 mm.

The abdomen of the female has been partially devoured by some predatory insect and only a portion of the wings remains beneath the tegmina, which have been displaced. I have much pleasure in naming this species after Dr. A. Smith Woodward, F.R.S.

Phyllodromia præcursor, sp. n. (Plate 7. figs. 6, 7.)

One male, No. 58505.

Rufo-testaceous. Antennæ fuscous. Pronotum trapezoidal, anteriorly not covering vertex of head, posteriorly scarcely produced, disc with a few obscure dark points. Tegmina and wings considerably exceeding apex of abdomen. Tegmina with minute castaneous points situated on the costal veins, at the base of the radial and ulnar veins, and on some of the ulnar rami ; mediastinal vein simple, radial vein bifurcate near apex, the lower branch ramose, about 12 costals, some of them bifurcate, discoidal sectors oblique, both ulnar veins ramose, anal vein impressed. Wings with mediastinal vein bifurcate. Cerci not visible. Subgenital lamina subtrapezoidal, symmetrical, with 2 genital styles. Front femora on anterior margin beneath armed with a few strong spines, which are succeeded distally by minute piliform spines ; remaining femora strongly armed ; genicular spines long.

Total length 12 mm.

In this specimen the right tegmen is lifted and extends at right angles to the body, so that its venation can be clearly seen ; unfortunately the underlying wing is almost completely covered by a portion of the left tegmen. The minutely maculate tegmina should enable this species to be readily recognised.

Pseudophyllodromia succinica, sp. n. (Plate 7. fig. 2.)

One example, No. 58616.

Head testaceous, with a narrow fuscous band on the vertex and two on the frons. Antennæ setaceous, rufescent. Pronotum transversely elliptical, testaceous, with two longitudinal fuscous vittæ. Tegmina long and narrow, fuscous, with the costal margin and the veins in the basal half pale testaceous ; about 9 costal veins, the last 3 ramose, posterior ulnar vein simple.

Total length 18 mm.

This is a mere fragment, the abdomen, legs, and ventral thoracic sternites having been destroyed, probably by some predatory insect, but the wing-venation and the type of coloration are eminently characteristic of the South American section of the genus *Pseudophyllodromia*. In my former paper on Blattidæ preserved in amber, I drew attention to the fact that, if any comparisons at all were possible between the Oligocene amber fauna and a modern tropical fauna, the Neotropical fauna was the only one which presented features of similarity with the European Oligocene fauna. It is, at any rate, noteworthy that amongst these scanty remnants of what was once an extensive Miocene insect fauna occurs a species which has its nearest allies in South America to-day. It is notoriously hazardous to draw conclusions from insufficient data ; I do not therefore seek to establish any theory on the facts just noted, but content myself with recording them, believing fully that one day their real significance will be established.

Ceratinoptera miocenica, sp. n.

One female, No. 58557.

General colour dark castaneous. Pronotum with anterior margin covering vertex of head, posteriorly slightly produced. Scutellum exposed. Tegmina corneous, barely exceeding apex of abdomen ; venation mostly indistinct, but anal vein deeply impressed. Abdomen piceous beneath ; subgenital lamina semi-orbicular, ample. Cerci not visible. Legs rufous, hind-femora with 6 spines on the anterior margin beneath, 6 or 7 on the posterior margin beneath.

Total length 8 mm.

The unique specimen is enclosed in a large block of amber in which are also embedded, besides several other insects of different orders, shreds and fragments of vegetable tissue; one such fragment conceals most of the ventral surface of the cockroach, and my description of the insect is therefore much shorter than I should like it to be. The strong armature of the hind-femora distinguishes the species from the four Oligocene representatives of the genus, noted or described by me in my former memoir, and to the best of my belief the species is also different from all known modern *Ceratinopteræ*.

? Periplaneta sp.

One female, No. 58652.

This is a larva and I refrain from giving it a name, as the adult may be found some day, and until that happens the exact generic position of this immature specimen must remain in doubt.

The general colour is pale ochreous, marked symmetrically with castaneous blotches. The supra-anal lamina is trigonal, its apex notched. The cerci

are long. The femora are moderately armed. The production backwards of the posterior angles of the meso- and metanotum shows that the adult must be a winged form.

Total length 14 mm.

EUTHYRRHAPHA PACIFICA, Coq.

Blatta pacifica, Coquebert, Icon. Ins. iii. p. 91, pl. 21. fig. 1 (1804).

One example, No. 58535.

The specimen is so enclosed in a block of amber that I am not able to make out much of the underside details, and therefore I cannot determine the sex with accuracy. The pronotum has a yellow spot at each posterior angle and the legs are dark castaneous, in which details the specimen resembles modern South African more than any South American specimens which I have seen.

The present range of the species is South America, Africa (including Madagascar), and Polynesia.

III. AFRICAN SPECIMENS.

Unfortunately the geological horizon of these specimens is unknown. I am willing, however, to hazard the opinion that it is much later than the Oligocene period. Only five genera are represented, viz., *Anaplecta*, *Ischnoptera*, *Phyllodromia*, *Periplaneta*, and *Plectoptera* *. The first and last of these genera may be considered as very highly evolved forms; their wing-structure is—if I may be pardoned the expression—*le dernier cri* in Blattid wing-evolution; and though we must exercise the utmost caution in our attempts to determine the duration of a species' existence from an examination of its structure alone, nevertheless I believe that the occurrence of such highly-evolved forms as *Anaplecta* and *Plectoptera* in amber is slight evidence in favour of presuming quite a late date for the horizon in which the amber is found.

All but one of the specimens are recorded from East Africa: the single exception has merely the label "Africa"; but as this specimen appears to me to be identical with one of the East African examples, I venture to assume that the *provenance* of all the specimens is the same. It is unfortunate that the exact locality where these specimens were collected is quite unknown.

ANAPLECTA sp.

One male, No. I 13769, with label "Africa"; one female, No. I 13761.

The numerous species of the genus *Anaplecta* are of small or minute size; they exhibit a very uniform type of coloration and the form of the terminal

* The determination of the genus *Periplaneta* is a little doubtful, as is shown later.

abdominal segments does not greatly vary. Consequently the systematist is compelled to fall back on the venation of the tegmina and wings in his efforts to discriminate between the species ; but this resource fails in the case of these particular amber *inclusa*, for their tegmina are pressed closely to the body and the merest vestige of one wing is visible. I see no object, then, in giving a name to a species which may be, for all I can tell to the contrary, identical with some modern representative of this very difficult genus, and which it is impossible to describe in detail. As a matter of fact, these amber specimens *look* very like rufous specimens of the modern West African *Anaplecta cincta*, Gerst., but very probably their wing-venation is totally different.

The following is a description of the specimens :—

Rufo-castaneous. Antennæ fuscous, not quite so long as the body. Pronotum transversely elliptical, its lateral margins hyaline. Tegmina with lateral margin in basal half hyaline ; discoidal sectors longitudinal. Subgenital lamina (♂) triangular, apex notched, (♀) semi-orbicular. Cerci testaceous. Legs testaceous, femora weakly armed.

Total length 5 mm.

Ischnoptera provisionalis, sp. n.

Two females, Nos. I 13764, I 13766.

Rufo-testaceous. Head with vertex not covered by anterior margin of pronotum ; a castaneous band between the eyes. Pronotum trapezoidal, posteriorly produced slightly ; disc indistinctly marked with castaneous. Tegmina and wings barely exceeding apex of abdomen. Tegmina with radial vein simple, 15–17 costals, 7 longitudinal discoidal sectors. Outer margins of the abdominal sternites and disc of subgenital lamina blotched with castaneous. Subgenital lamina semi-orbicular, ample. Cerci short. Front femora armed on anterior margin beneath with a few long and strong spines, succeeded distally by shorter spines ; remaining femora moderately armed.

Total length 15–16 mm.

This species presents so exactly the facies of those African species of *Ischnoptera* typified by *Ischnoptera bimaculata*, Gerst., that I have no hesitation in determining its generic position, even though the truly diagnostic character of the genus afforded by the wing-venation is not visible. I am less satisfied that the species is really distinct from all modern African species of *Ischnoptera*, and until the male sex is discovered I fear that this must remain uncertain ; the females of this group of the genus resemble each other so closely that their separation into species is excessively difficult even when the entomologist has fresh, pinned specimens before him. The

specific name which I have adopted for this amber-enclosed Blattid indicates the doubt with which I regard its identity.

PHYLLODROMIA INCLUSA, sp. n. (Plate 7. fig. 8.)

One male, No. 13765.

Pale testaceous. Antennæ longer than the body. Pronotum trapezoidal, anteriorly not covering vertex of head, posteriorly very slightly produced. Tegmina and wings exceeding apex of abdomen, but not by much. Discoidal sectors of tegmina longitudinal. Supra-anal lamina produced, quadrate, exceeding the apex of the subgenital lamina, which has the apex produced into an asymmetrical lobe; only one genital style, the left, visible. Cerci rather short, with 11 visible joints. Front femora armed on anterior margin beneath with 1–2 strong spines, succeeded distally by piliform setæ; remaining femora moderately armed.

Total length 12 mm.

PHYLLODROMIA sp.

One male, No. I 13759.

The block of amber in which the specimen is embedded has been so cut that it is impossible to get anything but a side view of the cockroach, and even this is obscured by the numerous cracks on the surface of the amber. Under these circumstances it would be unwise to describe the species. I can only say that it differs from the other species of the genus described from amber faunas by the prolongation of the left posterior angle of the subgenital lamina into a spiniform process.

Total length 13 mm.

PERIPLANETA sp. (Plate 7. fig. 1.)

Three larvæ, Nos. I 13760 (two specimens in one block), I 13767.

These larvæ, the largest of which is not nearly half-grown, look as if they might be the young of *Periplaneta australasiæ*, Fab., a modern, cosmopolitan species, but I think that they are not the same. I must, however, confess to ignorance of the very young larvæ of *P. australasiæ*; if I may judge from the many collections of Blattidæ which have passed through my hands no one has ever taken the trouble to acquire specimens illustrating the stages in the life-history of the species. Even the exact generic determination of this species is very doubtful; it is quite likely that the discovery of the adult will show that it must be referred to *Pseudoderopeltis* or even to *Stylopyga*. The figure illustrating the larger of the larvæ is of more value than many words of description, and will perhaps enable other investigators to decide if the species is distinct from *P. australasiæ* or not. The larvæ are bright ochreous marked with castaneous.

Plectoptera antiqua, sp. n. (Plate 7. fig. 9.)

One female, No. I 13758.

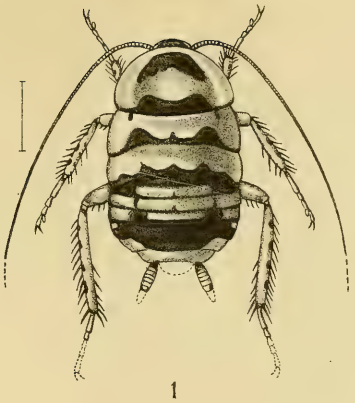
Rufo-castaneous. Antennæ elongate, setaceous, fuscous, with the last four or five joints pale. Pronotum transversely elliptical, anteriorly not covering vertex of head, sides hyaline. Tegmina hyaline ; mediastinal vein giving off some incomplete venules towards the outer margin, radial vein simple ; 10–11 rather irregular costals, many of these joined by transverse venules, a few venæ spuriæ between some of the costals and between the discoidal sectors. Apical field of the wings visible. Subgenital lamina small, apex only slightly produced, styles excessively small. Cerci straight, moderate. Legs testaceous ; all the femora entirely unarmed beneath.

Total length (excluding the unfolded wing-apex) 5 mm.

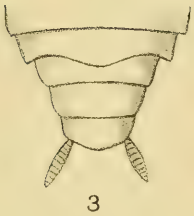
By a fortunate accident the apical field of the wing, which in this genus and in *Anaplecta* is normally doubled over the rest of the wing and hidden under the tegmina, has been unfolded in this specimen and projects far beyond the apex of the tegmina, so that there can be no doubt as to the generic identity of the species. Unfortunately, whoever was responsible for shaping the block of amber in which the insect is embedded, ground one face a fraction too much, with the result that one-third of the dorsal surface of the insect has been destroyed and the complete venation of the tegmina can no longer be observed. This venation is rather singular and the fraction that is visible suffices to discriminate the species from all the modern representatives of the genus.

The following is a list of all the species noted or described in the preceding pages, arranged in their systematic order :—

Subfam.		*Geological horizon.*	*Locality.*
Ectobiinæ.	*Ectobius balticus*, Germ. & Ber.	Oligocene.	Samland.
	Anaplecta sp.	?	Africa & E. Africa.
Phyllodromiinæ.	*Ischnoptera gedanensis*, Germ. & Ber.	Oligocene.	E. Prussia.
	„ sp.	„	Samland.
	„ *provisionalis*, sp. n.	?	E. Africa.
	Phyllodromia ? furcifera, Shelf.	Oligocene.	E. Prussia.
	„ *inclusa*, sp. n.	?	E. Africa.
	„ sp.	?	„
	„ *præcursor*, sp. n.	Miocene.	Stettin.
	„ *woodwardi*, sp. n.	„	„
	Pseudophyllodromia succinica, sp. n.	„	„
	Ceratinoptera miocenica, sp. n.	„	„
	Temnopteryx klebsi, Shelf.	Oligocene.	Samland.
Nyctiborinæ.	? *Nyctibora succinica*, Shelf.	„	„
Blattinæ.	*Periplaneta* sp.	?	E. Africa.
	„ „	Miocene.	Stettin.
Plectopterinæ.	*Plectoptera antiqua*, sp. n.	?	E. Africa.
Corydiinæ.	*Euthyrrhapha pacifica*, Coq.	Miocene.	Stettin.
	? *Polyphaga fossilis*, Shelf.	Oligocene.	Samland.



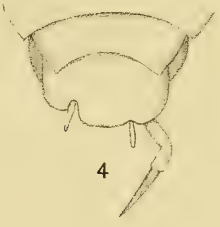
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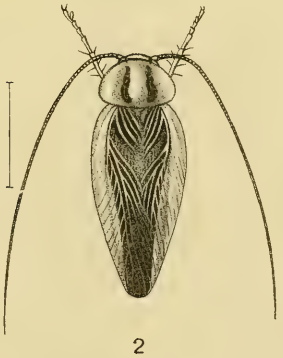
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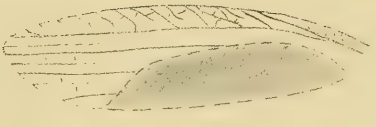
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7



6



9

H. Knight et R. S. del. (Westwood Bequest.)

E. Wilson, Cambridge

BLATTIDAE IN AMBER.

EXPLANATION OF PLATE 7.

Fig. 1. *Pleriplaneta* larva. (No. I 13767.)
2. *Pseudophyllodromia succinica*, sp. n. (The artist has represented the insect as a little too broad in proportion to its length.)
3. *Temnopteryx klebsi*, Shelf., ♂, apex of abdomen from above.
4. „ „ „ „ „ „ „ beneath.
5. *Phyllodromia woodwardi*, sp. n., ♂, apex of abdomen from beneath.
6. „ *præcursor*, sp. n., right tegmen.
7. „ „ „ ♂, apex of abdomen from beneath.
8. „ *inclusa*, sp. n., ♂, apex of abdomen from beneath.
9. *Plectoptera antiqua*, sp. n., portion of left tegmen.

N.B.—Figs. 1 and 2 are reproduced from drawings in the Geological Galleries of the Natural History Museum.

On the Occurrence of *Amphidinium operculatum*, Clap. & Lach., in vast Quantity, at Port Erin (Isle of Man).

By Prof. W. A. Herdman, F.R.S., F.L.S.

(Plate 8.)

[Read 1st June, 1911.]

In going to and fro between the village of Port Erin and the Biological Station, during the recent Easter vacation, I had occasion to take a short cut across the sandy beach at least twice and sometimes six times in the day. One gets into the habit, in these traverses, of looking closely at the beach when the tide is out, on the chance of seeing something of interest cast up. On April 7th, I noticed a new and quite unusual appearance on the sand at or a little above half-tide mark. The hollows of the ripple-marks and other slight depressions formed by the water draining off the beach were occupied or outlined by a greenish-brown deposit which in places extended on to the level so as to discolour patches of the sand (see Pl. 8. fig. 1).

Here the deposit remained, more or less, for a month—waxing and waning, sometimes increasing in a tide, say, roughly tenfold, and at other times apparently disappearing for a day or two and then re-appearing either on the same part of the beach, or it might be a few hundred yards away. At one time it discoloured a continuous stretch of sand about 50 yards long by 5 yards in breadth just below high-water mark, and was noticeable from some distance away.

At the first glance I supposed the appearance was caused by a deposit of Diatoms, but on taking a sample to the laboratory, microscopic examination showed that although a few diatoms (including *Navicula Amphisbæna* *, or a closely allied form) were present, the deposit was formed almost wholly of enormous numbers of a very active little Peridinian or Dinoflagellate of a bright yellow colour. More careful investigation enabled me to identify this form as *Amphidinium operculatum*, described by Claparède and Lachmann, in 1858, from specimens obtained at Christiansand, Bergen, and a few other places in Norway.

The published records of *Amphidinium*, however, do not give the impression that it is a common or abundant organism. The latest comprehensive work on such forms—the article on Peridiniales, by Paulsen, in the 'Nordisches Plankton' (Kiel, 1908)—recognises 4 species of *Amphidinium* : *A. crassum*, *A. rotundatum*, and *A. longum*, which as yet have been recorded from Kiel

* See postscript at end of this paper.

only; and *A. operculatum*, which is stated to occur in brackish water on the north coasts of Europe. In addition, Kofoid ('Dinoflagellata of the San Diego Region,' 1907), records *A. lacustre* from fresh water, *A. aculeatum*, a pelagic form from Naples, and *A. sulcatum*, which he took in a vertical haul from 90 fathoms in the Pacific.

On hunting through the few scattered references to *A. operculatum* which occur, one finds, however, that R. S. Bergh, in the 'Zoologischer Anzeiger' for 1882, states (p. 693) that Spengel in December and January found it in huge quantities on the beach at Norderney. Although, therefore, *Amphidinium operculatum* has been recorded once before as occurring in quantity, the occurrence appears to be a sufficiently rare event to be worthy of notice; and, so far as I can ascertain, the species, although known from several parts of North-west Europe, has not been previously found on the British coasts. I have written to most of the marine laboratories (Plymouth, Cullercoats, St. Andrews, and Millport) and to many marine biologists and have not been able to hear of any British record.

It is, however, not an unknown thing for rare Dinoflagellates to appear suddenly in some locality on an occasion in phenomenal quantities. Torrey, in the 'American Naturalist' for 1902, describes the unusual occurrence of a species of *Gonyaulax* on the coast of California. Sherwood and Vinal Edwards, in the 'Bulletin of the United States Bureau of Fisheries' for 1901, tell how for two weeks in September a *Peridinium* infested Narragansett Bay in such numbers as to colour the water blood-red and cause the death of many fishes.

Finally, Whitelegge, in the 'Records of the Australian Museum' for 1891, gives an interesting account of a new species of *Glenodinium* (*G. rubrum*) which appeared in such quantities in Port Jackson as to give the water "the appearance of blood" and cause the death of great numbers of oysters, mussels, and all forms of shore life. Whitelegge supposed that the very heavy rainfall that year, by affecting the salinity of the water, and then a lengthened period of calm weather which followed, may have provided favourable conditions for an unusual development of the Dinoflagellata. The *Glenodinium* appeared in vast numbers about the middle of March and disappeared early in May. When it was at its climax, the allied colourless species *Gymnodinium spirale* appeared in the bay and soon increased greatly in numbers and became finally even more abundant than the red *Glenodinium* upon which it was evidently feeding.

Returning now to our *Amphidinium operculatum*, it is not easy to account for the sudden appearance of this unusual Dinoflagellate (previously unrecorded in Britain) in such profusion on the beach at Port Erin last April. Plankton hauls were being taken regularly across the bay at the time, and they showed no trace of the organism. In fact, *Amphidinium* has not occurred in any of the thousands of gatherings which we have taken in the

Irish Sea during the last four years, and which have been examined in minute detail by Mr. Andrew Scott, A.L.S.

Thinking it might be present in the shallow water close to the edge of the beach, Mr. W. Riddell and I took some hauls of the tow-net from a punt worked backwards and forwards in a few inches of water as near as we could get to the discoloured sand, but the gathering, although it contained fine sand and mud, showed no trace of our Dinoflagellate. It may be noted here that although the size of the *Amphidinium*, 0·05 mm. in greatest diameter, is such that it can slip through the mesh (averaging about 0·08 mm.) of the finest plankton silk (no. 20), still so much clogging of the meshes always takes place in such hauls, and so many other smaller organisms and particles of mud are retained, that it is certain that had the *Amphidinium* been present in any quantity in the water it would have shown up in the gatherings.

Careful scraping of the sand showed that the Dinoflagellates were only in and on the surface-layer, and therefore could not be regarded as coming up from below. It occurred to us that possibly they might be fresh- or brackish-water forms derived from the land; but we ascertained that the little stream in the centre of the bay, which in wet weather overflows on to the beach (at other times it is conveyed into the town sewer), had not, on account of the unusually dry season, sent any water to the beach for some weeks. Moreover, on experimenting with the living *Amphidinium* in the laboratory, we found that while it lived well in sea-water it died at once in fresh and survived for a few days only in brackish water. Samples of the *Amphidinium* kept in shallow dishes of wet sand at the Biological Station in a few days showed such profuse growth that the sand was covered by a dark-coloured layer, the water became impure, and eventually all the Dinoflagellates died off.

Observation under the microscope shows that although this is a singularly active Dinoflagellate, circling round and round with great vigour, so that a drop of sand and water containing a number of the organisms presents a most animated picture under a low power magnification, still the *Amphidinium* seems to be actually attracted to the sand-grains and associated with them. The sand-grains in the field of view are always peppered over with a number of specimens of the *Amphidinium* (Pl. 8. figs. 2, 3, 4), and if individuals be watched they are seen after swimming round to come back to rest on a sand-grain and remain there for a time before starting off on another excursion. If they are thus constantly associated with sand-grains or other solid particles, and never swim more than a microscopic distance from such a resting-place, that may account for the fact that we have never found them in our plankton gatherings.

Amphidinium operculatum is also, however, positively heliotropic, congregating in quantity on the lighter side of the dish in the laboratory, and

shifting in bulk from the sand at the darker part of a tank to the end nearer the window. This property accounts for the invariable occurrence of the discoloured sand on the surface only and never in the deeper layers.

The published figures of this species are not very good, so a view of both dorsal and ventral surfaces, as seen under a high magnification, is given here (Pl. 8. fig. 5). There certainly seems to be a slight but definite cuticle covering the greater part of the surface, although this has been denied by some previous writers. The two characteristic Dinoflagellate grooves certainly join, as is stated by Calkins but not by other observers.

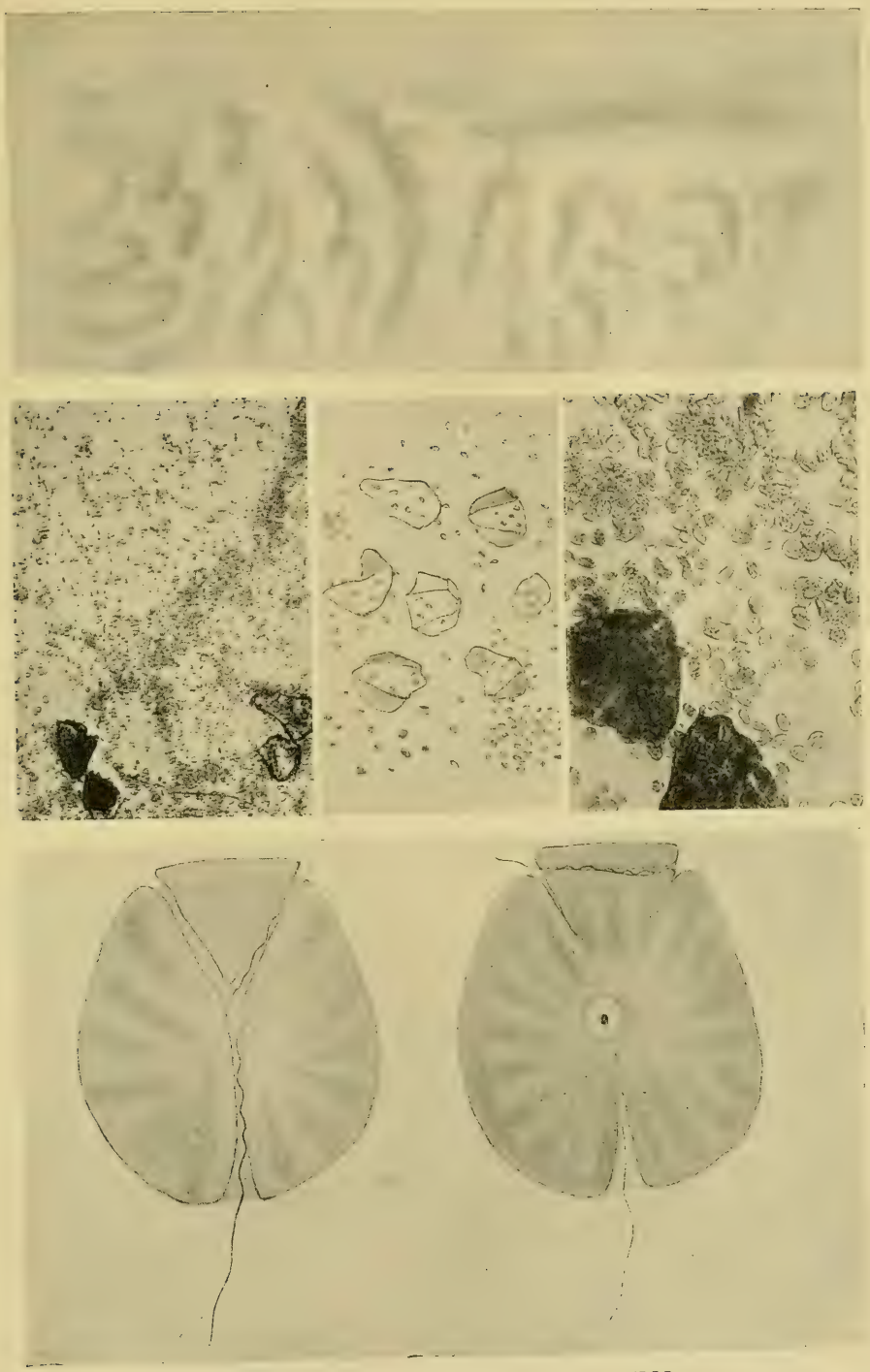
The posterior flagellum which projects freely from the body is not difficult to see, but the anterior one which lies along the transverse groove is not so easy to demonstrate, and may differ a little in position and extent from what is shown in the figure.

Stages in longitudinal fission were frequently seen, and that is probably the commonest method of reproduction. What appeared to be conjugation between two individuals was observed in one instance.

It may be that this organism lives normally in small quantities, so as not to be conspicuous, in some region of the sandy beach, or possibly in some special habitat beyond the beach, and that the present vast increase in numbers has been due to some unusual conjunction of circumstances ; but what these were I am not prepared to suggest. In the case of the Port Jackson *Glenodinium* plague, Whitelegge thought the increase may have been due to exceptional rainfall and calm weather; but the occurrence this spring at Port Erin was preceded by unusually dry, but rather stormy, weather.

I am inclined to think that, although I can find no previous record of such an occurrence, it is probable that these swarms of *Amphidinium* have been seen before at Port Erin, and possibly elsewhere. I fancy I have seen the phenomenon myself in the past, and have supposed it to be due to swarms of Diatoms, which certainly do cause some of the yellowish-green and brownish-green patches on the sand between tide-marks.

Postscript, *June 5th*, 1911.—Two days after reading the above paper before the Linnean Society I was again on the beach at Port Erin. I found in the same region what was apparently the same patch of discoloured sand, but on examining a scraping with the microscope found that the deposit was now wholly composed of a golden-yellow Naviculoid Diatom—one of the "*Amphisbæna* group" of *Navicula*. I have searched the beach carefully between tide-marks, and have examined samples from every suspected patch of sand, but can find no trace of *Amphidinium*. The *Navicula*, which was present in April in very small quantity (see above), seems to have completely replaced the Dinoflagellate. We have probably still much to learn in regard



AMPHIDINIUM OPERCULATUM.

to the comings and goings of such microscopic forms and their physiological inter-relations in connection with what may be called "the metabolism of the beach."—W. A. H.

Sept. 9th.—The *Amphidinium* is now back again in abundance, and the Diatoms are absent.—W. A. H.

EXPLANATION OF PLATE 8.

Fig. 1. The general appearance of the brown deposits in the ripple-marks on the sand, reduced in size.

2. Sand-grains and *Amphidinium* (photo-micrograph under low-power magnification).

3. Sketch from living preparation, to show some *Amphidinia* resting on the sand-grains and others swimming about (low power).

4. Part of fig. 2 under high-power magnification.

5. Dorsal and ventral views of *Amphidinium operculatum*—enlarged from high-power magnification.

For the photo-micrographs reproduced as figures 2 and 4, I am indebted to my friend Mr. Edwin Thompson.

Observations on some New and Little-known British Rhizopods.

By James Meikle Brown, B.Sc., F.L.S.

(Plate 9.)

[Read 4th May, 1911.]

During the examination of Rhizopod material collected from different localities in England and Scotland during the past few years, several interesting species have been obtained which I believe have not received previous notice as occurring in this country, and it seems desirable to put them on record. Some of these species are quite common in certain localities, while others, again, are apparently particularly rare, and do not seem to have been observed since they were originally described some years ago. Others, again, though repeatedly observed by their original discoverer, have not been met with by other naturalists. Further and more extended systematic work in this country will probably show that these last are more common than we at present believe.

Cochliopodium granulatum, *Penard*. (Plate 9. figs. 1 & 2.)

Penard, 'Faune rhizopodique' &c. p. 194.

In a collection of sediment containing *Amœbæ*, *Pamphagus*, &c., considerable numbers of this fine Rhizopod occurred. They were of large size, up to 80 or 100 μ, and in an active state. When disturbed the protoplasmic body is retracted and completely enclosed within the flexible test. In the active state a large mass of protoplasm flows out from the test, forming a broad expansion and giving off numerous pseudopodia. In this state the body plasma shows two distinct regions.

The included posterior part is greyish and granular, enclosing a distinctly-seen nucleus, which contains one or more "nucleoli,' and in the largest specimens many "nucleoli." Diatoms, green Algæ, and other food-bodies are enclosed in large numbers.

The extruded portion is relatively large in bulk. It is clear and hyaline, much vacuolated, and contains a great number of minute, oval, highly refractive bodies in very active movement. These occur in smaller numbers within the inner protoplasm, where they seem to be less active. Vacuolisation is sometimes so marked that the boundaries between the vacuoles are only rendered visible by the presence of these bodies.

The pseudopodia are numerous and hyaline, often branched, and in most cases obtuse. The protoplasm also exhibits wave-like outbursts. The test is flexible, deformable, and in the active animal in the form of a hemispherical

dome, with upturned margin. The margin is more flexible than the rest of the test and presents an irregular rim, generally outwardly and upwardly curved. In the retracted animal the "mouth" becomes completely closed.

The test exhibits a double contour with cross-striations. Under high powers, in surface view it shows numerous dots of different sizes, which take up stains (kresyl-blau and neutral-red), while the rest of the test remains unstained. In optical section the cross-striations are seen to correspond with the surface dots, which are, in fact, the ends of the cylindrical or rather double-cone-shaped structures of dense nature traversing a less dense non-staining matrix (Pl. 9. fig. 1 *a*).

Many young minute individuals were observed, identical with the large forms except that the nucleus contained one central chromatin body surrounded by a clear zone.

NEBELA BARBATA, *Leidy*. (Plate 9. figs. 3 & 4.)

Leidy, in Proc. Acad. Nat. Sci Philad. 1876, p. 119.
Leidy, 'Freshw. Rhizop. N. America,' 1879, p. 159.
West, G. S., Journ. Linn. Soc., Zool. xxviii. (1901) p. 323.
Compare Cash, 'Brit. Rhizop. and Heliozoa,' vol. ii. 1909, p. 113.

Leidy first described this species from examples taken from sphagnum in N. America, and although it possesses very definite characters, it has since frequently been confused with other species, and it is probable that very few naturalists have really seen it.

Dr. Penard, in 'Faune Rhizop.' p. 363, regarding the "cilia" or spicules of Leidy's description as probably parasitic growths, considers *N. barbata* as identical with Taránek's *N. americana* and discards Leidy's name as less suitable. Cash again (p. 113), both in his description and figures (pl. 27. figs. 5 & 6), confuses *N. barbata* with quite another form, which probably is to be identified with *N. tubulata*, Brown, but he gives also, as a text-figure, a drawing by West, which correctly shows *N. barbata*, taken in Llyn Llydaw, N. Wales. *N. barbata* has been found by the present writer in considerable numbers in Blea Tarn, Westmorland, a small tarn receiving drainage from sphagnum; and the individuals quite conform to Leidy's description.

N. barbata has a slightly compressed, flask-shaped test, with a cylindrical neck expanding very slightly at the mouth. This latter is oval, often with an irregular margin, and never possessing thickened lips or lateral notches. The test is transparent and generally covered with circular discs, sometimes slightly overlapping each other, with occasionally a few irregular flakes or sand-grains. The fine needle-like spicules are rigid and sharp-pointed, about 12 μ long, and project from between the plates. They occur scattered in large numbers on all sides of the test (*i. e.* they are not restricted to the lateral margins, as in many species of Rhizopod). These cils bear no

relation whatever to parasitic fungi, and can in no way compare with those shown in Penard's figure ('Faune rhizopod.' p. 356) and which are described as "short obtuse hyaline needles." The protoplasm is like that of Nebelas generally. Within the fundus it is crowded with yellowish food-bodies and diatom frustules, while within the neck a comparatively narrow band of clear protoplasm passes to the mouth, where it expands to the full width of the neck, and generally gives rise to one or two pseudopodia.

Size: length of test 100 μ; breadth 44 μ; width of neck 14 μ; length of cils about 12 μ.

NEBELA TUBULATA, *Brown*.

Nebela militaris, var. *tubulata*, Brown, in Journ. Linn. Soc., Zool. xxx. (1910) p. 365, pl. 50. figs. 9 & 10.

From the examination of individuals found in the English Lake District, this form was previously described as a variety of *N. militaris*, Penard. Since that time I have had opportunities of examining many specimens from different localities, including Stanage (Derbyshire), Duddon Valley (Lancashire), Scawfell and Helvellyn (Cumberland), Ben Ledi (Perthshire), Glen Shee (Perthshire), Stranraer (Wigtownshire) *. The characters are always quite distinctive and the animal shows little tendency to variation, and no transitional forms connecting it with *N. militaris* are met with. I therefore now regard it as an independent species.

In Cash's monograph, vol. ii. pl. 27. figs. 5 & 6 are named and described as *N. barbata*, Leidy. This is obviously an error, and the figures probably are to be identified as referring to *N. tubulata* (see remarks under *N. barbata*, *suprà*, p. 78).

NEBELA SCOTICA, sp. nov. (Plate 9. figs. 5–8.)

This Rhizopod was found in large numbers in sphagnum gathered from the middle slopes of Ben Ledi (Perthshire) in August 1910. The test is compressed, and in shape broadly pyriform, with rounded dome, which contracts abruptly into a short thick neck with lateral margins narrowing slightly to the borders of the mouth. In narrow view the dome is rounded, and the sides slope gradually to the mouth with only very slight concavity. The mouth is broadly elliptical with an irregular margin and no lateral notches. The surface of the test is somewhat variable, and sometimes inclined to irregularity. It is covered with transparent, colourless scales, occasionally almost rounded, at other times irregular in shape, of very variable size, and sometimes distinctly overlapping, with smaller scales overlying the corners where three or four scales meet (Pl. 9. figs. 8 *a* & 8 *b*).

* For the distribution in Scotland of this and other species of Rhizopoda, see my paper in the Ann. Scot. Nat. Hist. 1911, pp. 226-232.

All the plates appear corroded and the corners rounded, and cannot be confused therefore with mere foreign grains. Their general appearance and arrangement suggest *N. dentistoma* and *N. vitræa*, from which, however, this species differs in other respects. The mouth-scales are frequently larger than the others, and by their shape give the irregular margin to the mouth-opening. The protoplasm is similar to that of Nebelas generally. The individuals were frequently found encysted. The cysts were spherical and filled with granular matter. The mouth of the test was invariably closed by a laminated diaphragm, formed across the narrowed part of the test, while the mouth itself generally contained débris.

Size : length 78–82 μ ; breadth 57–59 μ ; thickness 40 μ; mouth 18–19 μ.

Though this species is remotely like *N. collaris* in shape, it cannot be confused with it ; the characters of the mouth and of the test are quite different. It appears more closely related to *N. dentistoma* or *N. vitræa*.

Nebela bigibbosa, *Penard*.

Penard, in Mém. Soc. phys. et hist. nat. Genève, 1890, p. 161 ; and Revue Suisse de Zool. 1905, p. 600, pl. 13. figs. 16–19 ; 'British Antarctic Expedition Reports,' vol. i. pt. vi. p. 240.

N. bigibbosa was originally described by Dr. Penard from material gathered at Wiesbaden. The same observer has more recently reported it from Valais, Spitzbergen, and from Vancouver and Victoria, but it never seems to have been found by other workers. The present writer has found it at High Lodore (Cumberland) and again in Glen Eagles (Perthshire), on both occasions amongst ground moss (not sphagnum). It is readily distinguished, not only by its general form but especially by the presence of two tube-like connections passing between the broad faces of the test. Active individuals were found on both occasions.

Capsellina timida, sp. nov. (Plate 9. figs. 9–13.)

This species was first discovered amongst moss growing on walls at Ecclesall, Sheffield, in November 1909. Later it also occurred amongst damp moss taken from the outside of a water-trough, also at Ecclesall, in which situation it has repeatedly been found since. In May, 1910, it was found amongst moss gathered at High Lodore, Derwentwater (Cumberland).

The body is ovoid, with a slight narrowing towards the mouth end, and with regularly rounded posterior extremity. It is compressed, more or less, and in extreme cases to almost half its width. The body is covered with a perfectly smooth, clear, transparent membrane. So far as observed it does not undergo deformation, but it seems sufficiently flexible to allow of this. Even under high powers the test appears to be structureless. There is no second external envelope of foreign matter, as is the case with *C. bryorum*, Penard. The structure and characters of the mouth agree perfectly with

Penard's description of that species. In the broad view of the animal, it shows a straight line running at right angles to the end of the body, due to the tight compression of the two incurved lips. In partial side view, two curved lines crossing one another represent the edges of the lips, which in narrow view disappear ; while an end view shows a straight line stretching nearly across the test. In most cases the mouth was closed tightly by compression of the lips (as may be inferred from the difficulty in getting stains to penetrate), but in one or two small individuals from High Lodore the lips were separated (see Pl. 9. fig. 12). Whether this is a natural state it is difficult to say.

The protoplasm fills the whole space within the test. It is colourless or greyish and contains many inclusions. Immediately within the membrane is a layer of brilliant droplets, of small size and highly refractive (oil). The general protoplasm contains many minute granules, together with larger food-bodies, including small green Algæ and even diatoms of considerable size. They show various stages of digestion and vary from yellowish to brownish. The size of the food-bodies observed demonstrates that the mouth is capable of considerable distension. In respect to the food-bodies this species differs very much from *C. bryorum*.

Several vacuoles occur. They originate in the protoplasm of the body and slowly move towards the mouth end, enlarging at the same time. Then somewhere in the neighbourhood of the mouth they disappear, but the process is not that of a sudden collapse, they seem to become lost gradually.

The nucleus is single, but not readily seen. It appears to contain a single spherical chromatin body, surrounded by a clear space. It is not of specially large size.

As is characteristic of most Rhizopods from the drier mosses, the animals seem remarkably shy under observation and rarely put out their pseudopodia. This may be due in large measure to the unnatural conditions under which they are examined. In the few cases when pseudopodia were seen, a small mass of clear protoplasm was noticed on the outer side of the test in the region of the mouth (which was not observed to be dilated), and from this a single fine filose pseudopodium originated, which by extension and contraction varied greatly in length. It was able to bend upon itself, and even swung round slowly as a whole. The movement of the animal is very similar to that of *Euglypha*, being of a somewhat jerky nature.

The animals have not been observed to divide. The process of division of *C. bryorum*, described by Penard, seems peculiar, in that the outer test is divided longitudinally at the same time as the inner body.

In some individuals the body protoplasm takes on a different appearance. It becomes broken up into numerous spherical bodies of about 3 μ diameter, which completely fill the test. This condition may possibly be connected with reproduction. In collections kept for some time, the protoplasm

gradually retracted from the test, became more spherical in form, and the nucleus became more visible (Pl. 9. fig. 11). This may have been preparatory to encystment.

The size of the animal varies slightly. Large specimens (adults) generally were about 34 μ long, 27 μ wide, and 18 μ thick, but smaller individuals were common.

It is interesting to notice that this species was discovered and examined before the author received a copy of Penard's paper describing the only other known species of the genus.

Euglypha bryophila, sp. nov. (Plate 9. figs. 14–15.)

At different times, amongst the drier mosses of woods, from districts as widely separated as Monsall Dale (Derbyshire), Port Patrick (Wigtownshire), Glen App (Ayrshire), and Kincardine O'Neil (Aberdeenshire), I have met with examples of a *Euglypha* which seems to me sufficiently characteristic to merit specific rank.

The test is very regular in form and subject to no marked variation. It is compressed and in broad view elongated oval, with rounded dome, and lateral margins gradually narrowing with even curvature to the borders of the mouth. In narrow view the dome is somewhat pointed and the lateral margins run in almost straight lines to the mouth. The outline is very even, and may compare with that of *E. lævis*, Perty.

The mouth is almost circular and bordered by six plates, each having one blunt rounded central tooth, with a minute lateral tooth on each side, often very difficult to distinguish (Pl. 9. fig. 14 *a*). The plates of the test are distinctly marked, are elliptical in shape, and arranged as in *E. alveolata*, but with some slight irregularity towards the mouth.

The crown of the test carries a cluster of four or five long, sharp, curved spines, of a nature similar to those found in *E. cristata*, Leidy.

The protoplasm is quite normal.

Size : length 50 μ ; breadth 23–25 μ ; thickness 16–17 μ ; mouth 9 μ; spines about 16 μ or more.

I was at first inclined to regard this as a variety of *E. cristata*, Leidy, owing to the presence of the cluster of spines, but this is the only respect in which the two forms are similar. *E. cristata* is quite peculiar amongst *Euglyphæ* in being very slenderly built and having a distinctly tube-like uncompressed form, with a very characteristic arrangement and appearance of the plates of the test. In none of these characters does the present species resemble it. Further, it is very unlikely that a variety of a species normal to sphagnum, which occurs in dry moss, would be of more robust build.

Dr. Penard, in 'Mém. Soc. phys. et hist. nat. Genève,' 1890, pl. 9. figs. 91 & 92, figures two individuals as broad forms of *E. cristata* which

might be identified with *E. bryophila*, but he makes no reference to this form in his later works.

PLACOCYSTA JURASSICA, *Penard*. (Plate 9. figs. 16–18.)

Penard, in Revue Suisse de Zool. 1905, p. 611, figs. 29 & 30.

This species has not previously been reported from England *. It occurred in comparatively small numbers in sphagnum gathered near Harrop Tarn (Cumberland) in May 1910, and again in sphagnum obtained near Stranraer (Wigtownshire) in September 1910.

P. jurassica differs from the more common *P. spinosa*, Leidy, in its smaller size (72–76 μ), its greater breadth in proportion to its length, its less compressed form, and especially in the character of its spines. These are not restricted to the margins of the test as they are in *P. spinosa*, but are distributed over its whole surface, though less numerous towards the middle of the broad faces. In form they are not broad flattened blades, but are fine "cils" like those of many species of *Euglypha*. They arise from the test at the points of junction of three plates (Pl. 9. fig. 18). (Penard's figure shows some of the spines arising from the middle of the plates themselves. This I have never seen.) At such points the cementing material is thickened in the form of a raised ring, in the central depression of which the "cil" is implanted. These rings appear as dots under low magnification, but under the higher powers their real character is demonstrated. Each ring would represent "le coussinet chitineux," which Penard describes in *P. spinosa*. In places, two or three spines arise together and then two or three annular formations occur in juxtaposition. The plates are much less regularly arranged, and are comparatively smaller and more numerous, than in *P. spinosa*. None of the individuals found were active.

SPHENODERIA MACROLEPIS, *Leidy*. (Plate 9. fig. 19.)

Leidy, 'Freshwater Rhizopods of N. America,' 1879, p. 232 and text-fig.

So far as I have been able to discover, no records of this species occur since Leidy's time. It must be one of the rarest species of Rhizopod.

Several individuals occurred, however, in sphagnum gathered near Stranraer (Wigtownshire) on September 1910. They are quite characteristic and cannot be confused with any other species.

Leidy describes the test as compressed, with a broad neck gradually extending from the body and terminating in the oblique elliptical mouth. The broad faces are occupied mainly by a pair of large hexagonal plates, from which the neck extends below.

* I find that Mr. W. Evans, in his Presidential Address to the Roy. Phys. Soc., Edin. 1906 (published 1909), notes *P. jurassica* as found by Mr. J. Cash in sphagnum from the Pentland Hills.

This is, indeed, the superficial appearance. When, however, the plates are examined with great care, it is seen that they are not, in fact, hexagonal. They are, in reality, more or less strongly bent, elliptical plates, with long axis lying transversely, and the upper and lower edges forming almost straight lines. They are overlapped slightly by the very strongly bent oval lateral plates, which cover the margin of the test. The result is the appearance of hexagons.

The mouth margins are without covering plates and are very flexible, often becoming folded back during manipulation.

The test is much broader in proportion than that of *S. lenta*.

Size: length 27 μ, breadth 20 μ.

AMPHITREMA WRIGHTIANUM, *Archer*.

Archer, in Quart. Journ. Micro. Soc. n. s. ix. 1869.
Penard, 'Faune rhizopodique' &c. p. 539.

This species occurred in several collections of sphagnum made in Scotland in August and September 1910, *e. g.* Stranraer (Wigtownshire), Ben Ledi (Perthshire), generally associated with *A. stenostoma*, Nüsslin, which seems the commoner species. Dr. Penard found it abundantly in the Jura, but states that until that time it had never been met with since Archer first described it from Ireland. It does not, however, appear to be at all uncommon in Scotland.

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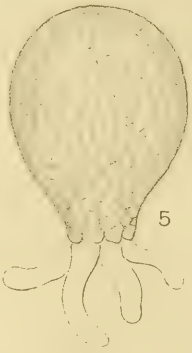
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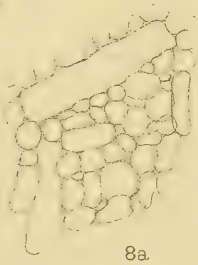

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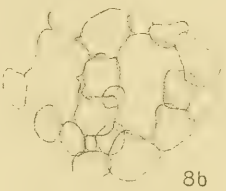

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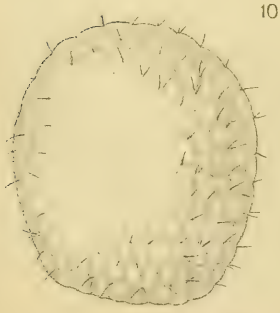

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J.M.Brown, del. E.Wilson, Cambridge.

BRITISH RHIZOPODS

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EXPLANATION OF PLATE 9.

Figs. 1 & 2. *Cochliopodium granulatum*, Penard. × 300. Fig. 1 shows the animal extended and fig. 2 shows it retracted almost within the test. Fig. 1 *a* is part of the test in optical section (more magnified).

Figs. 3 & 4. *Nebela barbata*, Leidy. × 400. Fig. 3 shows an individual in surface view and fig. 4 in optical section. Blea Tarn.

Figs. 5–8. *Nebela scotica*, sp. nov. × 380. Fig. 5 shows an active individual; fig. 6 an encysted animal in optical section; fig. 7 is the side view of an empty test in outline. Fig. 5 *a* is the mouth region of fig. 5, × 820; figs. 8 *a* and 8 *b* are portions of the test of two individuals, × 820. Ben Ledi.

Figs. 9–13. *Capsellina timida*, sp. nov. × 640. Fig. 9 is the side view of an active individual; fig. 10 is the semi-side view of the same; fig. 11 shows an individual (which had been kept for some time) contracting from the test; fig. 12 is a small specimen with open lips (from Lodore); fig. 13 is the mouth region of an individual with highly vacuolated protoplasm, × 1000. All except fig. 12 from Ecclesall (Sheffield).

Figs. 14–15. *Euglypha bryophila*, sp. nov. × 530. Fig. 14 is the broad view and fig. 15 the narrow view of an active animal. Fig. 14 *a* shows the inner face of a "mouth scale." Glen App.

Figs. 16–18. *Placocysta jurassica*, Penard. Fig. 16 is an empty test, × 530. Fig. 17 shows the mouth region, × 825, and fig. 18 a portion of the test, × 825. Near Harrop Tarn.

Fig. 19. *Sphenoderia macrolepis*, Leidy. × 930. Side view of an empty test. Stanraer.

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Nitocrameira bdellurœ, nov. gen. et sp., a Copepod of the Family Canthocamptidæ, parasitic in the Egg-cases of *Bdellura*.

By J. A. Liddell. (Communicated by Prof. G. C. Bourne, D.Sc., F.R.S., F.L.S.)

(Plates **10** & **11** and Text-figures.)

[Read 21st March, 1912.]

Occurrence.

The specimens from which this description is taken were obtained from *Limulus* which were kept in spirit for dissection, in the Department of Comparative Anatomy at Oxford. The precise locality from which the *Limulus* came is unknown, except for the fact that they were brought from America some twenty-five years ago.

The gills of *Limulus* are commonly infested by parasitic turbellarians of the group Bdelluridæ. Wheeler has described three species of these: in the egg-cases of two, *Bdellura candida*, Girard, and *B. propinqua*, Wheeler, which measure 2·5 to 4 mm. and 1·25 mm. respectively in length, a small copepod of the family Canthocamptidæ was found, for which I suggest the name *Nitocrameira bdellurœ*.

With regard to the occurrence of these egg-cases, those of *B. propinqua* were far more common, and were situated almost exclusively near the bases of the leaves forming the gill-books. Those of *B. candida* only occurred rarely and were generally full of eggs, but three empty cases were found to contain the copepod.

The much smaller cases of *Syncœlidum*, Wheeler, which are found at the margins of the leaves, never contained any inhabitants.

The copepod was only found in empty egg-cases, though a certain amount of organic débris was generally present, and in one case the remains of a turbellarian embryo were found.

They only occurred in egg-cases which were comparatively fresh. Older ones, much torn at the opening, or containing particles of sand and inorganic débris, were never occupied.

The number of copepods in each case varied considerably. One or two were sometimes found, but three to six seemed commoner. Larger numbers often occurred, one case containing 23 females and 6 males.

The number of males and females was approximately equal, the latter preponderating slightly.

Nauplius and metanauplius stages were also found in the same cases as their parents. Very few half-grown specimens were found.

Segmentation.

The adult *Nitocrameira* is minute, the total length being 1·26 mm. ·37 mm. of this length represents the caudal setæ. The body is slender and almost cylindrical, though somewhat compressed in the head region. There is no sharp demarcation between the thoracic and abdominal regions, and the segments are not sharply defined at the margins.

The third, fourth, and fifth thoracic segments are distinctly ringed, though fused to the head, and the limits of the second can be seen laterally. The first is thoroughly fused to the head, no marking being apparent between them.

The articulation between the fore and hind parts of the body, which occurs between the 5th and 6th thoracic segments, allows very free movement, and in many of the spirit specimens the abdomen is flexed dorsally so as to form almost a right angle with the cephalothorax.

There are four free abdominal segments excluding the telson, the first of which bears the genital aperture.

In the female the first and second are thoroughly fused, and no articulation nor any mark is apparent between them.

In the male the genital segment bears a pair of minute, indistinctly bilobed, setose projections, which may perhaps be regarded as the vestiges of a pair of appendages.

The eggs are carried in an egg-sac regularly arranged in a double row, and number from seven to twelve.

The spermatophore is pyriform, and hooked at the "neck" end.

The rostrum is small, narrow and conical. The caudal rami are short, and bear only a few setæ. The large seta is roughly one-third of the total length of the body. Another seta less than half this length lies externally to it, and there are three small setæ in addition.

The only structural trace *Nitocrameira* shows of its semi-parasitic existence is the extreme smoothness of the urosome.

The strong claw-like posterior ramus of the 2nd antenna of the Nauplius larva may also be a modification for attachment to the walls of the egg-sac.

Appendages.

1*st Antenna*.—The first antenna is eight-jointed, the third joint being in both sexes small, and bearing the greatest number of setæ.

In the female there is a distinct bend at the third joint. The fourth bears a long three-jointed æsthetasc. The last two joints are small, but quite well defined.

In the male the fourth and fifth joints are fused and expanded. The æsthetasc, which is blunter terminally than in the female, rises from the point of fusion of the two segments.

The joint which transforms the antenna into a grasping organ occurs between the fused fourth and fifth, and the sixth segments. The latter is provided anteriorly with four short tooth-like spines.

The seventh and eighth segments are smaller than in the female, and the joint between them is not so well defined.

2nd Antenna.—The second antenna is fairly long. The proximal joint is sub-divided, though not very distinctly. The outer ramus is small, uni-articulate, expanded distally, and bears three spines.

The distal joint of the antenna is expanded and bears three strong geniculated setæ, which are serrated on the hinder edge, distally to the geniculation.

There are also three more slender setæ anterior to these.

Mandible.—The mandible is simple. The biting-edge consists of a sharp, somewhat curved blade, and about fourteen minute teeth arranged in a double row behind the blade.

The palp is biarticulate with the proximal joint slightly expanded. The distal joint bears four long setæ terminally, and a shorter one laterally.

1st Maxilla.—The first maxilla consists of a large terminal lobe bearing three strong, somewhat curved spines. Anteriorly there are three lobes. The first two are a little shorter than the main lobe and each bears four setæ. The third lies at the base of the most anterior of these two. It is minute and bears two setæ, one long, the other short.

2nd Maxilla.—The second maxilla ends distally in two lobes, each bearing a stout curved spine and a slender seta. There is also a single seta anteriorly.

Maxilliped.—The maxilliped or first thoracic appendage is biarticulate and ends in a stout recurved spine. The swollen distal joint is setose on its anterior edge, the whole forming a subchelate prehensile hand.

1st true legs.—The first true legs or second thoracic appendages are biramous, each ramus consisting of three joints. The endopodite is narrow and much longer than the exopodite, but its middle joint is short.

The number of plumose setæ is reduced, there being only one on the proximal joint, one on the middle joint, and a spine and two plumose setæ terminally on the distal joint.

In the exopodite there is only one plumose seta on the inner side, instead of three as in the second, third, and fourth legs.

There are three terminal setæ, and four external spines, the last two of which are slightly plumose.

The second, third, and fourth true legs only differ from each other in the relative length of the plumose setæ and spines, and in the relative sizes of the endopodite and exopodite. The latter is largest in the third pair of legs, and the setæ are longest in the fourth.

The fifth legs or sixth thoracic appendages are reduced in both sexes to expanded terminal and proximal joints. Those of the male are less reduced, and more like those of the female than is usual in the family.

In both sexes the distal joint bears six setæ, the apical seta in the female being stout and remarkably long.

In the male the internal expansion of the proximal joint bears three setæ, and in the female five setæ. There is an external seta on this joint in both sexes.

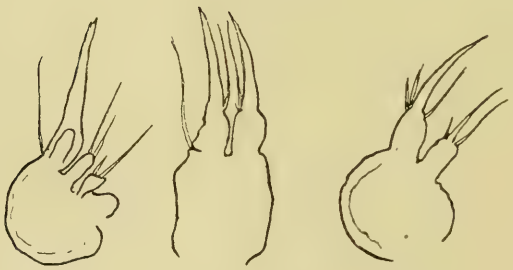
Max. I.



Nitocra. *Nitocrameira.* *Ameira.*

Fig. 1.

Max. II.



Nitocra. *Nitocrameira.* *Ameira.*

Fig. 2.

Classification.

Nitocrameira does not fall under any recognized genus, according to the generic characters given by Sars in his Monograph on the Crustacea of Norway.

The two genera it approaches most nearly are *Nitocra* and *Ameira*.

In its general appearance it resembles the latter, owing to the smoothness

of its urosome, but in a large number of other important characters its affinities are with *Nitocra*.

The simplest way of showing its resemblance to these genera, is by arranging the generic characters of the three genera in tabular form (see p. 92).

With regard to the 1st maxillæ of *Nitocra* and *Ameira*, Sars's figures do not help to make the description very clear.

That of *Nitocra* is described as having the exopodal and epipodal lobes defined, and the accessory lobe wanting.

Sars's figures, as will be seen in text-figure 1, show three setiferous lobes in front of the jaw-like terminal portion, as is also the case in *Nitocrameira*.

That of *Ameira* is described as having the exopodal and epipodal lobules not defined and the accessory lobe present.

The figure shows two setiferous lobes anterior to the jaw-like portion.

The resemblance of the 2nd maxilla of *Nitocrameira* to that of *Ameira* is shown in the second text-figure.

Life-History.

The life-history and habits of *Nitocrameira* are necessarily incompletely known, but a certain amount can be deduced from the specimens found.

It is evident that reproduction takes place in the egg-cases.

The figure shown in fig. 3 (Pl. 10) contained two females and one male. Each female has a brood of eggs, and also a brood of larvæ. Numerous other cases were found containing numbers of larvæ with their parents.

No stage was found between the older larvæ shown in fig. 3 and half-grown adults. The inference is that the egg-case is left by the larvæ when they have reached the stage of development shown in fig. 3. They then lead a free swimming existence until half or three-quarters grown, when they enter a fresh egg-case for their reproductive life. In cases that contained large numbers of copepods, as for instance that with 29, the aperture was so small and the inmates so tightly packed, that it seems evident that they entered when very small.

They might have been hatched in the same egg-case in which they were found, but it is difficult to see where the food would come from.

In practically all individuals the gut was well filled, the food probably consisting of embryo triclads. Generally the organic detritus present was so macerated as to be unrecognizable, but in one case the half-devoured remains of an embryo were certainly present.

Literature.

Wheeler.—Journal of Morphology, ix. 1894, p. 167.

Sars, G. O.—An Account of the Crustacea of Norway. Vol. v. parts xvii. and xviii. p. 211 *seq.* 1907.

Tabulation of Generic Characters of :—

	Nitocra.	*Nitocrameira.*	*Ameira.*
Body	Slender, cylindric.	Slender, somewhat compressed anteriorly. A.	Slender, somewhat compressed anteriorly.
	Coarsely spinulose urosome.	Practically smooth urosome. A.	Less spinulose than *Nitocra.*
Anal opercle.	Denticulate at edge.	Smooth. A.	Smooth.
Caudal rami.	Short and covered with spinules.	Short, almost smooth. A.	Short, scarcely spinulose.
Rostrum ...	Very small, narrow, conical.	Small, narrow, conical. N.	Almost obsolete.
Ant. I.	Moderate size, 8-articulate, densely fringed with setæ; last two joints not very reduced.	Moderate size, 8-articulate. densely fringed with bristles; last two joints distinct. N.	Last two joints very small, not well defined.
Ant. II.	Outer ramus short, uniarticulate, dilated distally.	Outer ramus short, uniarticulate, dilated distally. N.	Outer ramus uniarticulate and narrow.
Mandible ...	Palp biarticulate, basal joint slightly dilated.	Palp biarticulate, basal joint slightly dilated. N.	Mand. palp more developed, basal joint dilated into a setiferous expansion.
Maxilla I. ...	Three lobes inside jaw-like portion.	Three lobes inside jaw-like portion. N.	Two lobes inside jaw-like portion.
Maxilla II. .	Two setiferous lobes inside terminal claw-bearing part.	A single claw-bearing lobe, inside claw-bearing part. A.	Only a single lobe (setiferous) inside the terminal claw-bearing part.
First pair of legs.	Rather strongly built, distinctly prehensile. Inner ramus 3-articulate, with outer two joints more or less bent on inner.	Somewhat more slender than *Nitocra.* Inner ramus much longer than outer, 3-articulate, last joint as long as first. A.	Distinctly prehensile, but more slender than *Nitocra.* Inner ramus much longer than outer and distinctly 3-articulate.
Natatory legs.	Rather fully developed, with inner ramus of all distinctly 3-articulate, and not transformed in male.	Well-developed; both rami 3-articulate, inner not transformed in male.	Both rami well developed, 3-articulate, inner not transformed in male.
Last pair ..	Distal joint compressed. Large inner expansion of proximal joint fairly produced.	Distal joint long and compressed. Inner expansion of proximal joint not much produced. Male much less reduced in comparison than either *Nitocra* or *Ameira.*	Small distal joint, more or less contracted distally. Inner expansion of proximal joint not much produced.

Letter N denotes resemblance to *Nitocra.*
Letter A denotes resemblance to *Ameira.*

SUMMARY.

Nitocrameira bdelluræ, nov. gen. et sp., from egg-cases of *Bdellura propinqua*, Wheeler ; and less frequently those of *Bdellura candida*, Girard.

HARPACTICOIDEA, family CANTHOCAMPTIDÆ.

Genus NITOCRAMEIRA.

Body. Long, smooth, almost cylindrical, somewhat compressed anteriorly. Rostrum small ; caudal rami short.

Ant. I. 8-jointed, setose anteriorly, last two joints well-defined. 3-jointed æsthetasc on segment 4. Female antennæ bent at 3rd joint. Male 4th and 5th joints fused ; whole forming a strong clasping organ.

Ant. II. Basal joint sub-divided ; outer ramus uniarticulate and much reduced.

Mandible. One cutting-blade and crown of short teeth. Palp biarticulate, proximal joint slightly expanded. Distal joint only, bears setæ.

Maxilla I. Expanded jaw-like portion bearing three spines and two almost equal lobes and a third very minute setose one anteriorly.

Maxilla II. Two lobes with stout terminal spines.

Maxilliped. Subchelate prehensile hand.

Thoracic legs. Endopodite and exopodite three-jointed, except last which is reduced.

First pair prehensile, last pair much reduced, but more similar in male and female than is usual in the family.

In some generic characters resembles *Nitocra*, in others *Ameira*.

EXPLANATION OF THE PLATES.

PLATE 10.

Fig. 1. *Nitocrameira*, female, lateral view. Partly diagrammatic as the appendages of the right side only are shown.

2. View of last thoracic and first abdominal segments of male, showing last thoracic limbs, rudimentary abdominal appendages, and spermatophore.

3. Egg-case of *Bdellura propinqua* containing one male and two female *Nitocrameira*. Each of the females has a brood of developing eggs, and two stages of larvæ ar shown, six of each stage.

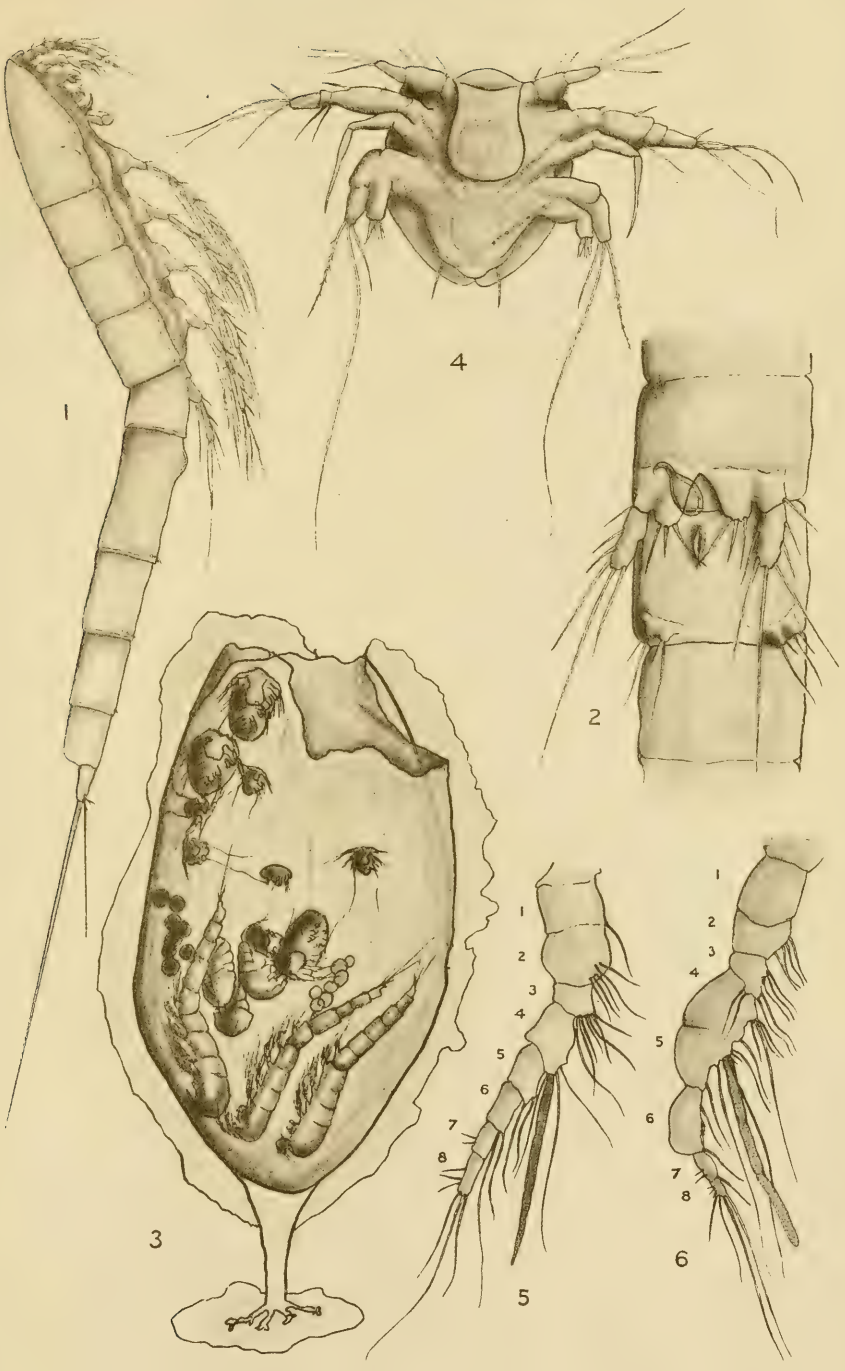
4. Young Nauplius larva about ·09 mm. long. This was the commonest larval stage that occurred.

5. First antenna of female.

6. First antenna of male.

PLATE 11.

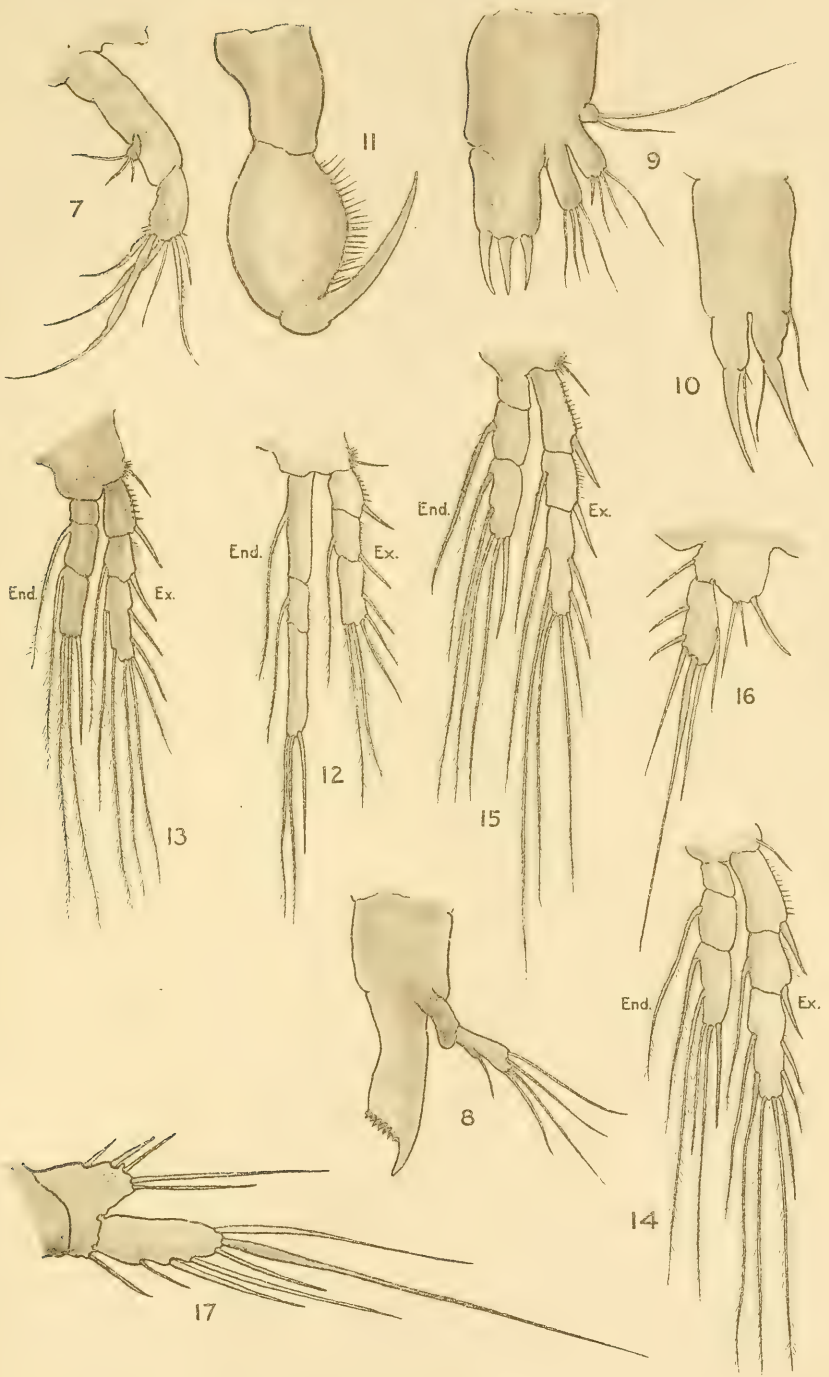
Fig. 7. Second antenna of male.
8. Mandible. The anterior side is to the right.
9. 1st maxilla. „ „ „ „ „
10. 2nd maxilla. „ „ „ „ „
11. Maxilliped. The anterior side is to the right.
12. First thoracic swimming leg.
13. Second „ „ „
14. Third „ „ „
15. Fourth „ „ „
16. Fifth or reduced leg, male.
17. Fifth or reduced leg, female.



J. A. Liddell, del.

Grout, Intaglio et imp.

NITOCRAMEIRA BDELLURAE.



J. A. Liddell, del.

Grout, Intaglio et imp.

NITOCRAMEIRA BDELLURAE.

Some Annelids of the Thames Valley.

By the Rev. Hilderic Friend, F.L.S., F.R.M.S.

(With Text-figures.)

[Read 21st December, 1911.]

I am anxious at the outset to guard against the idea that the Thames Valley, any more than other parts of England, has been exhaustively worked. We are familiar with a goodly number of worms, particularly those belonging to the two families known as the Lumbricidæ and the Tubificidæ. We know something also of the Naïdidæ, but of the large and important family of the Enchytræidæ we are still in almost absolute ignorance, in spite of the fact that some 30 species of the genus *Fridericia* alone are already recorded as British.

I have chosen the Valley of the Thames, rather than the river itself, as my field, because I am thereby enabled to draw attention to the excellent work done by those able pioneers who have prepared the way for my own more recent researches. The greasy, fœtid ooze of our great river does not present a very attractive hunting-ground for the naturalist: yet the treasures it contains will amply reward the worker who has the courage to ignore its evil odours, or to risk the covering of his boots with a most disagreeable slime.

Although the Thames Valley has as yet been but partially worked, there is perhaps no section of the country which has received so much attention in relation to the Oligochæts. It is a pleasure, therefore, in the first place to give

A BRIEF HISTORICAL SURVEY.

I do not pretend to have looked up every detail, but have endeavoured to do justice to all who have done anything to further our knowledge of the subject since the days when the study of terrestrial and freshwater annelids became a scientific pursuit. The honour of being first in the field in this connexion undoubtedly belongs to Sir E. Ray Lankester. Not less than forty years ago (1) he recorded the discovery of *Psammoryctes barbatus*, Vejdovsky, in brackish water at Barking. The worm still exists in the same locality, and will be considered again at a later point. In June 1898 Dr. Benham wrote (2) that, so far as he was aware, the species had not been recorded again till he found it in the mud amongst the roots of reeds in the Cherwell.

In the eighties at least three workers were adding to our knowledge of the subject. Oerley (3), a most careful and advanced Hungarian student, was working in England at this time, and among other discoveries found *Octolasium platyurum*, Fitz., at Cambridge, and *O. rubidum*, Oerley, at Woolwich. These records have not since been confirmed, but Oerley has so

thoroughly impressed me with his accuracy and conscientiousness that I am still hoping to rediscover the species named. While he was working with the larger earthworms, Bourne (4) and Bousfield (5) were rendering splendid service by their researches among the Naïdidæ. It is enough at this point to refer to the Journal of this Society (Zoology, vols. xix.–xx.) for evidence of the careful and valuable work of Dr. Bousfield. The next important contribution to our subject came from the pen of Dr. Benham (2), and it may perhaps be said that he did for the Tubificidæ what Bousfield and Bourne had done for the Naïdidæ. His "Notes on some Aquatic Oligochæta" for the first time opened up the great and important field of research presented by the large and interesting group of worms of which *Tubifex* is the type. While some of his material came from the mouth of the Thames, being supplied by Mr. W. H. Shrubsole of Sheerness, other species were found in the neighbourhood of Oxford, which forms the limit of our field inland.

Of Beddard (6) it must suffice to say that his splendid 'Monograph of the Order Oligochæta' was an epoch-making book, and gave so great a stimulus to research that if it were brought up to date it would have to record many hundreds of new species. He is undoubtedly the highest authority this country has ever produced on the subject of Oligochæts.

My own researches into this order began in 1890. During that year I found some annelids in London which had not previously been recorded, and by the aid of some indefatigable collectors was able to do a good deal of work among the Lumbricidæ and Enchytræidæ (7). I must specially mention Mr. George Day, F.R.M.S., and Mr. William Allen of Plaistow. During the past twenty years I have worked at Oxford, Marlow, Kew, the suburbs of London, and Sheerness, and have had the kind assistance of Mr. Chas. S. Todd, of Tottenham, and others, to whom my thanks are due for help. Aided by a Government Grant for these researches I have, during the past year (1911), paid a special visit to the Thames Valley, and am able as a result to add a number of species to our former lists, some of which are new to science. We may now pass to a systematic study of the species which are found in the district under review, and for convenience of reference it may be desirable to follow the order adopted by Beddard, and still more recently by Michaelsen (8).

SYSTEMATIC SURVEY.

Family ÆOLOSOMATIDÆ.

Michaelsen places in this family one certain and one doubtful genus. To the genus *Æolosoma* he allots seven species, and no new species has been added to the six which are on record for Great Britain. These annelids are

all of small size, and are found in fresh-water in almost every part of the globe. There are usually no internal septa to mark the segments, which can, however, easily be numbered by aid of the setæ. These are in four bundles of one to six, chiefly capilliform. The girdle appears in the adult on the under surface of segments 5–7, and the spermathecæ, which number 1–3 pairs in segments 3–5, are simple, being destitute of diverticula. The prostomium is large in proportion to the size of the worm, and is ciliated on the ventral surface. The worm can be propagated asexually, by a process of division without the formation of a budding zone such as one sees continually in the Naïdidæ.

1. Æolosoma headleyi, *Beddard*. (Monograph, p. 186.)
Setæ entirely capilliform. Integumental globules bright green, occasionally verging towards blue. Found in a tank at the Zoological Gardens, London.

2. Æolosoma hemprichii, *Ehrenberg*. (Symb. Phys. 1831.) For synonymy see Beddard, 'Monograph,' p. 183, and 'Das Tierreich,' x. p. 14; Lankester in Trans. Linn. Soc. vol. xxvi. 1867, p. 641.

Family Naïdidæ.

This is a very large family, to which many additions have been made since the publication of Beddard's 'Monograph' and of 'Das Tierreich.' Unfortunately the British species have received little attention since the days of Bousfield and Bourne, but I have been able during the past year to add somewhat to our knowledge of the indigenous species. The setæ are sometimes wanting in the anterior segments either entirely or from the dorsum, and are of various kinds. Some of the species have rudimentary eyes, and asexual as well as sexual reproduction occurs. The sexual organs are situated as far forward as the fifth segment. Occasionally the nephridia fail, but usually they are large for the size of the worm. These annelids form beautiful objects for the microscope. Following Michaelsen our first genus is *Paranais*.

1. Paranais naidina, *Bretscher*. (Revue Suisse de Zool. 1896, vol. ii. p. 508; 1899, vol. vi. p. 393; Das Tierreich, x. p. 18.)
Unknown in England till August last, when I found it in the Thames at Kew. Eyes may be present or absent. The first segment is very narrow, and the dorsal setæ commence on the second. There are five or six setæ in each set from segments 2 to 5. The brain is deeply notched behind. The worm is about 8 mm. in length, and in August was undergoing asexual reproduction, some 20 segments going to the perfect worm. Found by Bretscher (10) in Switzerland (Zürich).

2. Paranais litoralis (*O. F. Müll.*) *Czern.* (Zool. Dan. 1788; syn. *Uncinais*, Beddard, Monograph, p. 295.)

Has a blunt prostomium. Setæ vary in length and thickness. The subject of some interesting notes by Benham and Bourne. The worm was received by the former, along with other aquatic annelids, from Sheerness: Benham (2), p. 187.

3. Chætogaster diastrophus, *Gruith.*, Benham (2), p. 212; near Oxford.

4. Chætogaster diaphanus, *Gruith.* (The synonymy is given by Beddard and Michaelsen.)

Southern (9) marks its occurrence in England and Scotland with a query, but I have recently been able to demonstrate its indigenous character beyond doubt, since it occurs plentifully in the neigbourhood of my home.

5. Chætogaster crystallinus, *Vejd.* (*Cf.* Lankester, Trans. Linn. Soc. xxvi. (1869) p. 641.)

For the various species of *Nais* and *Dero* it suffices to refer to Bousfield and Bourne. I have, however, to add one species to the list, and as I can find nothing exactly corresponding with it in the various authorities, it must for the present be held to be new to science.

6. Dero olearia, sp. n.

Forked setæ beginning in 2nd segment ventrally; 4–5 per bundle, slender, as long as half the diameter of the body; the upper tooth larger than the lower, and the node in the middle, or approaching the first (inner) third. The dorsal setæ begin in segment 6; each bundle consisting of one capilliform and one forked seta. There are three forked setæ of equal length in the ventral bundles posteriorly, but the setæ in the anterior ventral bundles vary slightly and progressively in length, the dorsad being longer than the ventrad. The forked setæ of the dorsal bundles are more slender and straight than those found in the ventral sets, and the teeth are small. Length of entire worm 8–10 mm.

The chloragogen cells, which are black, begin in segment 6 along with the capilliform setæ. At rest the prostomium equals the individual setigerous segments in length, and is 3–4 times as long as the peristomium, or first segment, which carries no setæ and is exceedingly small. No taste-hairs or papillæ are present. The segments number 40; there was no sprouting zone or bud, nor was a girdle developed. Eyes are wanting.

The living worm is exceedingly active, swimming freely in water, but breaking up almost as soon as it is placed on the microscopic slip, even if not subjected to pressure. This makes it difficult to work out the details. I believe it has the gills which distinguish *Dero* from *Nais*; and a special character is

the large number of clear oil globules, which after 15 hours in glycerine remained unaffected. Hence the specific name. The first six segments remained intact when all the rest of the worm broke up at the septa into five and thirty pieces. Septa are wanting in this cephalized portion.

One specimen collected at Kew in August, and kept with other annelids till December 8th, 1911, when it was examined. It closely resembles *D. stuhlmanni*, Stieren, reported from the Victoria Nyanza; but the African worm is only 2 mm. in length and has but 18 segments (Michaelsen, 'Das Tierreich,' x. p. 29).

7. Stylaria lacustris (*Linn.*) *Johnst.* is one of our commonest worms.

8. Pristina equiseta, *Bourne*. Botanical Gardens, Regent's Park, London.

Family Lumbriculidæ.

Aquatic worms of much larger size than the Æolosomatidæ and Naïdidæ. The type (*Lumbriculus variegatus*, O. F. Müll.) often attains a length of 80 mm. and may have 200 or more segments. The sigmoid setæ are in pairs, and the free extremity is sometimes forked. With the exception of *Stylodrilus* (and *Bichæta*?) there are, in this family, blind contractile appendages to the blood-vessels. These are well seen in *Lumbriculus variegatus*, and give to the animal a very beautiful appearance. There are no penial setæ. Only two of the genera are at present known in the Thames Valley.

1. Lumbriculus variegatus, *O. F. Müll.*, Verm. terr. 1774.

Body usually dark green in front. Posteriorly there are 6–8 cæcal appendages to the dorsal vessel in each segment. Very rarely found in the adult condition. The worm often divides into two or more portions when handled or under examination. One of the commonest species of freshwater annelids in England, it occurs in almost every pond, ditch, and stream in the district among water-weeds. Yet I sought it in vain at Sutton Broad in August.

(*Rhynchelmis*. Beddard says, 'Monograph,' pp. 215–16 :—"I have seen a specimen from some part of England, but cannot give any details. There is every probability that it is a native of the country. I believe this specimen to be in the Oxford Museum." So far as I can recall, Benham, who worked at Oxford, makes no allusion thereto, nor have I been able on the occasion of my visits to obtain specimens or information.)

The genus *Stylodrilus* consists of worms which are marked by the possession of a pair of penes on the tenth segment which are not retractile but remain as external appendages, perforated by the sperm-ducts. The setæ are bifid,

but in some cases the forks can be seen only with fairly high powers of the microscope. A pair of spermathecæ is found in segment 9, and the girdle usually extends over 9, 10, and 11.

2. Stylodrilus vejdovskyi, *Benham*. (Quart. Journ. Micr. Sc. vol. xxxiii. 1891, p. 209.)

Twenty-five mm., more or less, in length, with penes a little more than half the diameter of the body. First discovered in the River Cherwell, it has since been found by me in many parts of England, but more frequently in the North and Midlands than in the South. It is interesting to see the locality "Goring-on-Thames" in 'Das Tierreich,' x. p. 63. For details we must refer to the original paper by Benham as above.

Family Tubificidæ.

This large and interesting, but perplexing family has been the subject of very special and painstaking investigation during the past year: and though I have not yet by any means worked out all the problems connected therewith, I have at least reduced some of the chaos to order. I had the honour, on December 20th, 1911, of presenting to the Royal Microscopical Society some of the results of this enquiry, and may be permitted to refer those who are interested in our fresh-water Annelids to that Memoir for such details as may not be given herewith (**11**). An old record informs as that specimens of *Saenuris tubifex*, or some other "Small red Water-worms (are) found plentifully in the mud of the river Thames" (Johnston, 'Catalogue of British Worms,' p. 64). Such worms abound everywhere in the Thames, and it is impossible as yet to say to how many species or genera they belong. Perhaps the first reliable record is the following:—

1. Psammoryctes barbatus (*Grube*) *Vejd.* (=*Tubifex umbellifer*, Lankester, Quart. Journ. Micr. Sc. xi. 1871, p. 181; Ann. & Mag. N. Hist. ser. IV. vii. 1871, p. 92.)

Found at Barking, then, as now, in brackish water. See Benham (**2**) p. 208, where will be found a useful note, especially in relation to the setæ.

As I do not follow Michaelsen in placing *Heterochæta* and other genera under *Psammoryctes*, this is the only species of the genus to be recorded for the Thames Valley at present. The species, however, is not limited to brackish water, as Benham found it in our district among the roots of reeds in the Cherwell, and I have taken it at Stratford-on-Avon and elsewhere.

2. Heterochæta costata, *Clap.*

The anatomy and histology of this species (Benham (**2**), p. 188 *seq.*) form what one may call the first classical study of British Tubificidæ. Specimens

were received by Dr. Benham from Mr. W. H. Shrubsole, of Sheerness, in the spring of 1891. Since then I have repeatedly studied it from different localities between the Nore and the Tower Bridge. I take this opportunity of expressing my great indebtedness to Mr. Chas. S. Todd, of Tottenham, for valuable consignments from many localities, containing a large proportion of the species recorded in this connection.

3. Hemitubifex benedeni (*Udek*). (Recorded by Benham with the foregoing as *H. ater*.)

Found in dark, evil-smelling, decaying organic detritus at Sheerness, and thence to the City. Received from Mr. Topps-King, of Chatham, quite recently.

4. Spirosperma ferox, *Eisen*.

Benham says (2, p. 207): "I have found specimens in the Thames and in the Cherwell."

5. Clitellio arenarius (*O. F. Müll.*) *Sav*.

Benham (2, p. 187), from Sheerness.

6. Branchiura sowerbyi, *Beddard*.

Regent's Park and Kew Gardens: still abundant, with other interesting aquatic annelids, some of which will be named below. For a recent study of this worm reference may be made to the paper of Dr. J. Stephenson, presented to the Royal Society of Edinburgh, December 4, 1911.

We come now to more recent studies, which not only confirm the foregoing records, but greatly extend our knowledge of the Thames Valley Tubificidæ.

7. Monopylephorus parvus, *Ditlevsen* (1904: Zeit. wissen. Zool. Bd. 77, pp. 426–8, figs. 25 & 26).

As there can be no doubt about the identity, I transcribe my own notes. "Thames at Kew. Lily pond in Kew Gardens: collected August 26, 1911. Tower Bridge: collected by Mr. C. Todd, Sept. and Dec., 1911. A tiny worm 6–10 mm. in length; very slender: segments 65. Straw-coloured or yellow-brown. Head somewhat pointed when in motion, front segments with narrower and wider annulus. Chloragogen cells begin in segment 5. Setæ usually three in front, four in a few instances, declining to two and one posteriorly. Nephridia with small anteseptal without covering cells; postseptal very large. Dorsal vessel with heart-like enlargements, ranging in some instances from the fifth to the ninth segment. Brain with a lobe at each of the posterior corners and strong anterior processes. Sperm-funnel about twice as long as broad; ducts with peritoneal cells. Two sets of three setæ only on segment 11, with an unpaired male pore between. This refers it to *Monopylephorus*. The setæ here do not differ from those of the other

segments. No penial setæ present; no penis present." A further note is added, "Posterior setæ with upper tooth smaller than the lower: the node at the outer third." I have material still under observation in the hope of finding specimens in the adult condition. In my judgment *Vermiculus* (Goodrich) and *Bothrioneuron* (Stolč = *Bothrioneurum* as corrected by Michaelsen) are synonyms of *Monopylephorus*.

The genus *Limnodrilus* has, perhaps more than any other, grown under my investigations. I have not only to record the occurrence of the species which have long been known to science, but venture to submit some new descriptions.

8. Limnodrilus hoffmeisteri, *Clap.*

The most widely distributed species in the genus. Found almost everywhere in the Thames Valley where mud can be obtained perennially.

[Since I began the preparation of this paper I have had further opportunities of studying this ubiquitous species. I find that the Thames specimens taken at the Tower Bridge and elsewhere show one or two strongly marked varieties as well as what might be called the typical form. I am now engaged in studying the earlier authorities with a view to determining which is the type and which the variety. Meanwhile, to avoid confusion, and to aid in the clearing up of difficulties, I have defined one variety in my account of the British Tubificidæ, and named it *L. hoffmeisteri*, var. *tenellulus*.]

9. Limnodrilus udekemianus, *Clap.*

Almost as ubiquitous as the last (Mém. de la Soc. de Phys. de Genève, xvi (1862) p. 243).

10. Limnodrilus claparedianus, *Ratzel*, Zeit. wiss. Zool. 1868, p. 590.

Seems not to have been found till the present year. Taken at Kew, August 1911. I think it may have been confused at times with one of the other species of *Limnodrilus*.

In view of the conflicting statements of the authorities respecting the length of the penis-sheath in the above three species I am subjecting them to careful measurement. Differences certainly appear to occur; but when we have eliminated the errors which are due to inaccurate observation and confusion of species, these differences will either disappear or be reducible to a trustworthy term.

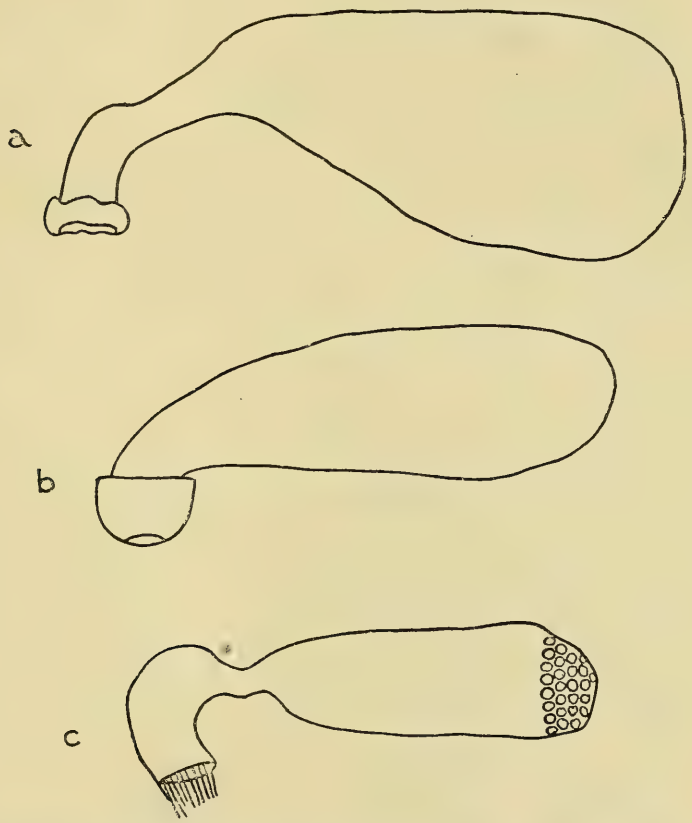
11. Limnodrilus longus, *Bretscher*. (Revue Suisse de Zool. vol. ix. (1909) pp. 204–5, figs. 2 & 3.)

The original description is very brief: "Intestine begins in segment 5. Setæ in front bundles 5. Penis-sheath straight or slightly bent, over twenty times longer than broad; reaching through segments 10–12." The note which follows adds nothing to these facts. Southern (9, p. 136) says that "in the Irish specimens the length of the penis-sheath was 21 times the breadth.

Bretscher gives 20 to 1 as the proportion." (This is not exactly true, for Bretscher says "Penisscheide *über* 20-mal langer als breit"). "The sheath has a broad and shallow funnel-like expansion at the distal end. The anterior nephridia are enveloped in bladder-like cells. The length is 20–25 mm., and there are 4–7 setæ in the anterior bundles."

My own notes are as follows:—"*L. longus*, Bret. In mud from Tottenham: collected by Mr. C. Todd, September 1911. Length 1 inch (=20–25 mm.).

Fig. 1.



Spermatheca of (*a*) *Limnodrilus longus*, (*b*) *L. galeritus*, and (*c*) *L. aurantiacus*.

Segments about 90. Head small. Setæ 4–6, 7 in the front segments, the teeth about equal, slender, not coarse like those of *L. udekemianus* and *L. papillosus*; dwindling behind to 3 and 2, with teeth rather wider apart. Chloragogen cells (= intestine) beginning in segment 5. Penis-sheath *very* long; duct the longest I have yet observed, with large pyriform prostate and atrium. Spermathecæ somewhat pear-shaped, narrowing gradually (fig. 1 *a*) into a short duct. Brain somewhat concave in front with convex sides. Not deeply lobed."

The next four species, new to science, are based on specimens collected by myself or Mr. Todd in and around London in August and September of the present year (1911). It may be thought by some that the absence of a penis-sheath would justify the creation of a new genus, but I do not myself regard such action as necessary, especially as that organ may yet be discovered *. I have at present two species which are not known to possess that organ. The first is—

12. Limnodrilus papillosus, sp. n.

First collected at Kew, August 26th, 1911; since obtained from the Thames near London, and various localities in Sussex, Nottinghamshire, and Derbyshire. The specimens from Sussex differ from the type, but being out of our present district are unnoticed. The Kew notes are as follows :— "Length from 1–2 inches, nearly 1 mm. in diameter in front, with 180 segments. Setæ, 5–7 in front, 3–4 in middle and 2 in posterior segments. Brownish red, with fleshy head and yellowish tail, gradually tapering from the thickest part. Head short, rounded. Large hearts in 8–9. Spermathecæ present, but no penis-sheath. Chloragogen cells begin in 5 or 6, large, dark, circular, when set free." The Kew specimens are the largest I have seen, and differ somewhat from the others in colour, and some minor details. I attribute this to the fact that the Kew specimens have been introduced, and life is higher : the specimens found in Derbyshire being located in stiff loamy soil, and showing a tough, papillose integument of a yellowish hue, often approaching a dirty orange. Again, my notes respecting a typical specimen found in the Midlands are as follows :—"Length 25–30 mm., 90–120 segments. Setæ usually five in front bundles, upper tooth much larger than lower. Pharynx in 2–3 ; ventral setæ wanting on segment 11. Spermathecæ in 10, a simple sac ; no spermatophores seen ; striate, not cellular or glandular. Nephridia large ; two pairs in front of girdle in 6/7, 7/8, then in 13 and the following. The vascular system in front segments not complex."

Thus it will be seen that this species differs in many ways from the earlier forms. The absence of penis-sheath, the presence all over the body of papillæ, the shape of the nephridia, and the vascular system all differentiate it from *L. udekemianus*, which it resembles chiefly in the shape and size of the setæ.

13. Limnodrilus galeritus, sp. n.

Chloragogen cells begin in fifth segment. Setæ 4–5 in segments 2–7, and usually three in middle of body, with upper tooth rather larger than lower, in anterior bundles, and teeth equal behind. Efferent duct very long. Spermathecæ without a distinct duct, but with a cap at the external opening

* Pointner (**12**) has created the genus *Isochæta* for these species.—H. F., May 25, 1912.

(fig. 1 *b*). Penis-sheath long, intermediate between *L. hoffmeisteri* and *L. longus*; nearly straight, slender, with trumpet-shaped extremity. Setæ one-sixth the length of the penis-sheath.

From the River Lea, Tottenham. Collected by Mr. C. Todd, September 1911, in company with the next.

14. Limnodrilus trisetosus, sp. n.

A small, tender worm, of 40 segments or more. Length about 10 mm. Front segments biannulate. Setæ three throughout. This is a very unusual arrangement in this genus, seeing that the rule is for the number to decrease behind the girdle. No ventral setæ near the male pores, dorsal setæ present on girdle-segments. Lower tooth somewhat larger than the upper. Pharynx reaches to end of segment 3; chloragogen cells begin in 5, and from the girdle backwards orange and black cells are intermixed, as in *L. aurantiacus*, Fr. Nephridia very large in middle segments. Brain slightly concave behind. Spermathecæ pear-shaped, without distinct duct. No spermatophores at present seen. No penis-sheath, but a widening of the duct near the male aperture. Nerve ganglia in front segments with extensions as in *L. nervosus*, Friend.

River Lea, Tottenham, September 1911.

15. Limnodrilus aurantiacus, *Friend*. ('The Naturalist,' 1911, p. 414.)

Length 6–8 mm. and upwards; 60 segments; brilliant orange-coloured cells in segments 8–20 or thereabouts. Setæ usually five in segments 2–8, and three behind; varying in size. Penis-sheath slightly bent, about thirteen times longer than broad. Brain roundish with slight concavity behind. Pharynx reaches to posterior end of segment 4. Spermathecæ (fig. 1 *c*) with narrow neck nearly midway between ampulla and duct. Nephridia of tail with very tiny anteseptal.

Kew Gardens, August 28, 1911. Since found in many other localities around London and in the country.

The genus *Ilyodrilus* as defined by Eisen and Stolč needs revision in the light of my recent discoveries around London and elsewhere. Hitherto, no one has been able definitely to prove the presence of this genus in England, although Benham long ago suggested that Lankester probably had some species of *Ilyodrilus* under examination when he referred to the membrane found stretched across the teeth of some of the setæ. This suspicion is abundantly confirmed by my discovery of species of *Ilyodrilus* in the Thames, at points not far removed from, if not identical with, those from which Lankester's specimens were drawn. In my study of the British Tubificidæ [Journ. R. Micr. Soc., 19th June, 1912, p. 268] I have named five species

of *Ilyodrilus*, all new to Britain, and two new to science. Of these, three species are at present known to occur in the Thames Valley, and there is every reason to believe that the number will shortly be considerably increased.

[*Note added May 25th*, 1912, *in place of further descriptions.*

The recent researches of Bretscher, Piguet, Ditlevsen, Pointner, and others have resulted in so great an extension of our knowledge of the Tubificidæ, and at the same time have revealed so confused a condition, that it is deemed advisable to withhold the descriptions of these species of *Ilyodrilus* and *Tubifex* till greater certainty prevails respecting their definition.

The Enchytræidæ and Lumbricidæ also remain to be described.]

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The Correlation of Somatic Characters and Chromatin Rod-Lengths, being a Further Study of Chromosome Dimensions.

By C. F. U. Meek, M.Sc., F.L.S., F.Z.S.

(With 5 Text-figures.)

[Read 20th June, 1912.]

Introduction.

In a recent paper * dealing with chromosome dimensions in numerous organisms, I have shown that throughout the animal kingdom lengths of component rods appear to constitute members of a general series in arithmetical progression, whereas only three diameters exist, viz. ·21 μ in Protozoa, and ·42 and ·83 μ in low and higher Metazoa respectively.

Consideration of the results given has, moreover, led to the enunciation of an hypothesis which postulates a series of cycles in the course of phylogeny. It is suggested that the chromatin granules of the simplest Protozoa have been converted into rods by purely linear growth, accompanying evolutionary development and increasing somatic complexity, and, since the rate of this growth cannot have been the same in all chromosomes, rods of various lengths have been evolved ; examples of such complexes can be seen in *Ciliata* and other highly differentiated Protozoa. A stage in phylogeny was later reached when a maximum rod-length had been attained, such limit having been imposed by spindle mechanism or other physical conditions ; when this occurred chromatin units conjugated in fours, and the normal thread-width was thus doubled. The chromosomes, reduced in number, then segmented transversely into numerous spheres of the new diameter, and the process, which approximately re-established the number of chromosomes previously seen, enabled them to enter a fresh course of linear growth accompanying further evolutionary development. In this manner the complexes of low Metazoa may have evolved from those of Protozoan ancestors.

When the length-limit of chromosomes was again reached, conjugation of units once more occurred, and this was followed as before by segmentation into spheres of the new diameter ; the last named having been thus doubled, became identical with that now found in organisms belonging to phyla above and including Nemathelminthia. Thus the chromatin thread-width of the high Metazoa may have evolved from that of the lower.

This hypothesis seems to accord with phenomena, for I have been able to find in the animal kingdom examples that apparently represent stages of

* "A Metrical Analysis of Chromosome Complexes," Phil. Trans. Roy. Soc. ser. B, vol. 203, 1912.

transition to a greater thread-width: it is, however, impossible to prove this phylogenetic cycle with the meagre data at present available. If it is eventually established, we must realize that an attempt to correlate somatic characters and individual chromosomes must fail the moment that we consider any but the most closely allied organisms: at definite periods a complete rearrangement of units has occurred, and, since the subsequent rate of growth must have varied in different chromosomes under different conditions of environment, we have no reason for assuming correspondence between rods of the same length found in the germ-cells of widely separated organisms. Within the limits of a genus, however, it may be possible to trace somatic differences to differences in chromatin growth, for closely allied animals must have developed along the same or parallel lines, and we may therefore be able to identify corresponding chromosomes in their respective complexes. In the paper already referred to I have given camera lucida drawings of chromosome rods composing the complexes of several species of *Stenobothrus*, and have shown that the latter can be individually distinguished by the presence or absence of certain rod-lengths; I now propose to deal with another species of this genus in order to show that this phenomenon is probably common to all its members. Moreover, the comparative study of allied species may enable us to establish some correlation with respect to length of chromosomes and somatic characters.

Material and Methods.

Stenobothrus curtipennis, which belongs to the tribe Tryxalidæ and the family Acridiidæ, is not found in the British Isles, and I am indebted for the material to the kindness of Prof. H. S. Davis, who sent me testes fixed in Hermann's solution and embedded in paraffin, from the University of Florida, Gainesville, U.S.A. The sections were cut 8 μ thick and stained with Heidenhain's iron hæmatoxylin, the mordant used being an aqueous solution of iron alum. The preparations were studied by means of a Zeiss apochromatic oil-immersion objective of 2 mm. focus and N.A. 1·30, in conjunction with compensating oculars nos. 6, 12, and 18: I have used throughout the holoscopic oil-immersion substage condenser made by Messrs. Watson, of High Holborn, London.

All drawings were made with the aid of a large Abbe camera lucida at a magnification of three thousand and forty-eight diameters, the magnification being estimated by means of a stage-micrometer graduated to read one-hundredth of a millimetre. When necessary, resolution was facilitated by interposing a Gifford screen.

In order to avoid error due to foreshortening, drawings have been made only of chromosomes that lay at right angles to the microscopic line of vision

throughout their entire length, and errors in draughtsmanship have been minimised by drawing each individual chromosome many times; the measurements given should therefore represent the true dimensions with as great accuracy as can be obtained with the means now at our disposal.

Spermatogenesis.

The testes are two ovoid bodies lying in the middle of the abdomen dorsally to the alimentary canal; they are composed of tubular follicles tapering towards the ends and divided into numerous tracts and cysts. The primary and secondary spermatogonia lie at the extreme anterior end of each follicle, and next to these are large areas occupied by cells undergoing the growth-period; no resting stage occurs between the maturation mitoses, and the next portion of the follicle is accordingly occupied by both primary and secondary spermatocyte divisions. The posterior end contains spermatids undergoing transformation to unripe and ripe spermatozoa. As I have already pointed out in the case of *S. viridulus*, all cells in one cyst are not at precisely the same stage of development, and in a transverse section mitotic figures and resting stages can be seen lying side by side.

The primary spermatogonia are arranged in a cluster at the extreme anterior end of the follicle, whereas the secondary spermatogonia, more posteriorly placed, are in greater numbers and appear to be without definite arrangement in the cyst. The chromatin during the resting stages is disposed in granules upon linin threads, and the nucleus is apparently a complete reticulum. In the prophase of division this network breaks into numerous filaments, which shorten and condense until seventeen compact and smooth chromosomes are seen lying in the equatorial plane; these are divisible into eight pairs and one odd chromosome, which corresponds with the monosome of Davis and the heterotropic, accessory, and X chromosome of other writers.



Fig. 1.—Spermatogonial metaphase.

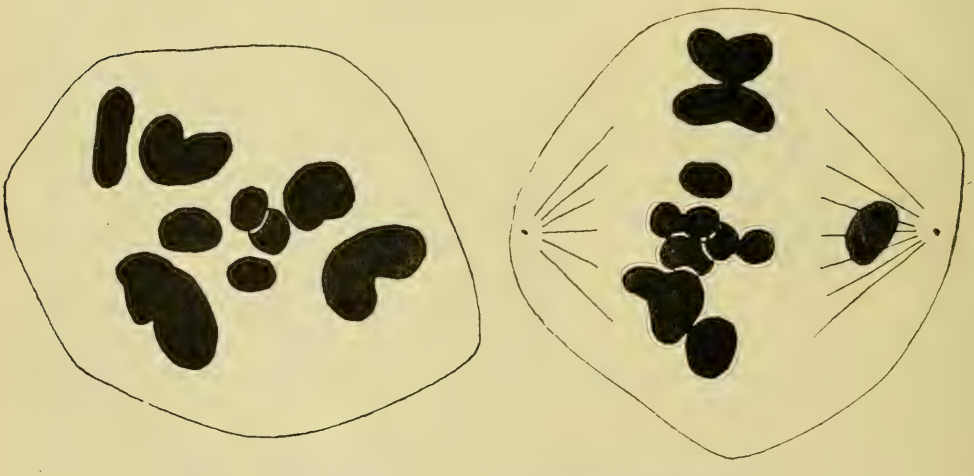
The sixteen ordinary chromosomes are graded in length and individually composed of two equal rods, of which one passes to each pole in the subsequent anaphase: the plane of cleavage is invariably parallel to the major axes of these rods, which appear to be indivisible units. The diameter of the ordinary rods is constant, whereas that of the odd chromosome is greater and varies throughout its length; the latter is thus easily distinguishable from

the other members of the complex. Fig. 1 shows a polar view of this metaphase, and seventeen chromosomes are seen in the equatorial plane.

The last spermatogonial division is followed by a long period of growth, and large tracts of the follicle are seen occupied by cells undergoing this stage. The chromatin is again disposed in granules upon a network of linin threads, but the odd chromosome takes no part in the general dissociation and remains as a darkly staining and homogeneous body apposed to the nuclear membrane. The prophase of the first maturation division is characterized by the fission of individual granules and the breaking of the network into numerous double filaments ; these, which are at first long and ragged, conjugate in pairs and condense into the usual tetrads, appearing as rings, crosses, and figures of eight. The closeness with which the component rods are folded upon one another makes resolution extremely difficult, but size-relationships corresponding with those seen on the spermatogonial spindles are again recognizable, and each tetrad is undoubtedly composed of four equal rods in juxtaposition. Since these rods are similar to those of the earlier mitoses, the total amount of chromatin remains unchanged, and the



Fig. 2.—The Growth Period.



Figs. 3 & 4.—Polar and lateral views of first maturation mitosis.

eight tetrads are collectively equivalent to the sixteen ordinary spermatogonial chromosomes. I have failed to determine whether this division is reductional or equational, but this is immaterial, for either this or the next mitosis must separate paternal and maternal elements. Figs. 3 and 4, representing respectively polar and lateral views of this division, show the eight

tetrads and the odd chromosome, and in the latter the odd chromosome is seen passing entire to one pole, while the ordinary chromosomes are preparing for or actually undergoing fission in the equatorial plane.



Fig. 5.—Second maturation mitosis.

The second maturation division immediately follows the first, and the complex is composed of eight or nine chromosomes, the difference depending upon the odd chromosome, which is found in only 50 per cent. of these cells. As in the case of the spermatogonial metaphases, each ordinary chromosome is composed of two equal rods, and the same size-relationships are again apparent. Fig. 5 is an example of this metaphase seen from the polar aspect.

The transformation from spermatids to unripe and ripe spermatozoa is similar to that already described for these organisms by myself and other writers. The chromosomes become dissociated into minute granules, which at first stain only slightly with the iron hæmatoxylin ; the appearance of the "centrosome" is accompanied by elongation of nucleus and cytoplasm, the latter eventually constituting a long thread-like tail.

Dimensions of the Chromosomes.

The diameter of all component rods of the ordinary spermatogonial chromosomes is ·83 μ, and these consequently differ from one another only in length. The complex is divisible into two groups represented respectively by three long and five short pairs: this grouping accords with that of Davis, and with my own upon other members of the genus. Moreover, the lengths of the component rods of the five short pairs are respectively 1·7, 2·1, 2·5, 2·9, and 3·3 μ, and therefore constitute consecutive members of a series in arithmetical progression ; those of the three long pairs also belong to this series, but are alternate instead of consecutive, being respectively 5·0, 5·8, and 6·7 μ.

The tetrads or primary spermatocyte chromosomes cannot be measured accurately for their outlines are irregular, but a careful study of the filaments condensing during the preceding prophase leaves little doubt that they are individually composed of rods of the above dimensions.

The secondary spermatocyte complex is the most favourable for the measurement of chromosomes, since overlapping does not occur and individuals are composed of pairs of rods as in the spermatogonial mitoses. The diameter of the component rods of ordinary chromosomes is again ·83 μ, and the lengths are respectively 1·7, 2·1, 2·5, 2·9, 3·3, 5·0, 5·8, and 6·7 μ, *i. e.*, identical with those of the spermatogonia. The odd chromosome, found

in 50 per cent. of these cells, is again easily recognizable on account of its great breadth. I have already produced evidence to show that rods composing ordinary chromosomes of organisms above and including Nemathelminthia have a constant diameter, viz. ·83 μ, and that their lengths constitute members of a general series in arithmetical progression ; and the chromosome measurements of *S. curtipennis* therefore afford further support to this assumption.

The accompanying figure (fig. 6) shows the complexes of *Stenobothrus parallelus*, *S. viridulus*, *S. bicolor*, and *S. curtipennis*, the four complexes being respectively marked A, B, C, and D. In my recent paper I have identified rod-lengths of the general series by numerals, which are again used and are placed above the corresponding chromosomes. The drawings show component rods, each spermatogonial and secondary spermatocyte chromosome being composed of two and each primary spermatocyte chromosome of four.

The rod-lengths of the five short chromosomes appear to be the same in all four species, whereas those of the three long chromosomes are not identical in any two : in *S. parallelus* they correspond respectively with Chromosomes 14, 15, and 17 of the general series, in *S. viridulus* with Chromosomes 13, 15, and 17 ; in *S. bicolor* with Chromosomes 11, 13, and 17, and in *S. curtipennis* with Chromosomes 11, 13, and 15.

If now we assume that the chromatin is directly concerned with the transmission of the hereditary characters—and we have many reasons for assuming this—we must look for the cause of somatic differences between these species in the three long chromosomes, for the respective nuclei appear to differ only in the lengths of these. Moreover, we must try to discover how these differences in rod-lengths have occurred, for the problem of chromosome function must be intimately connected with such differences.

Let us firstly assume that chromosome rods throughout the animal kingdom are of fixed lengths, and that morphological similarity is invariably accompanied by functional similarity. This assumption carries with it the further assumption that in the course of evolution certain rods have disappeared from each complex, local conditions having determined which should persist and which should be eliminated : moreover, it postulates a greater number of chromosomes in primitive than in highly organized types, and we must expect to find allied organisms possessing many chromosome lengths in common. The former of the last-named corollaries is, however, not supported by actual investigations, and with regard to the latter I have already shown that *Forficula* does not possess one rod-length in common with *Stenobothrus*. We are accordingly faced by a complete contradiction, for, if a definite chromosome rod-length is invariably correlated with a definite set of somatic characters, no such set of characters can be possessed by both earwings and grasshoppers—members of sister families.

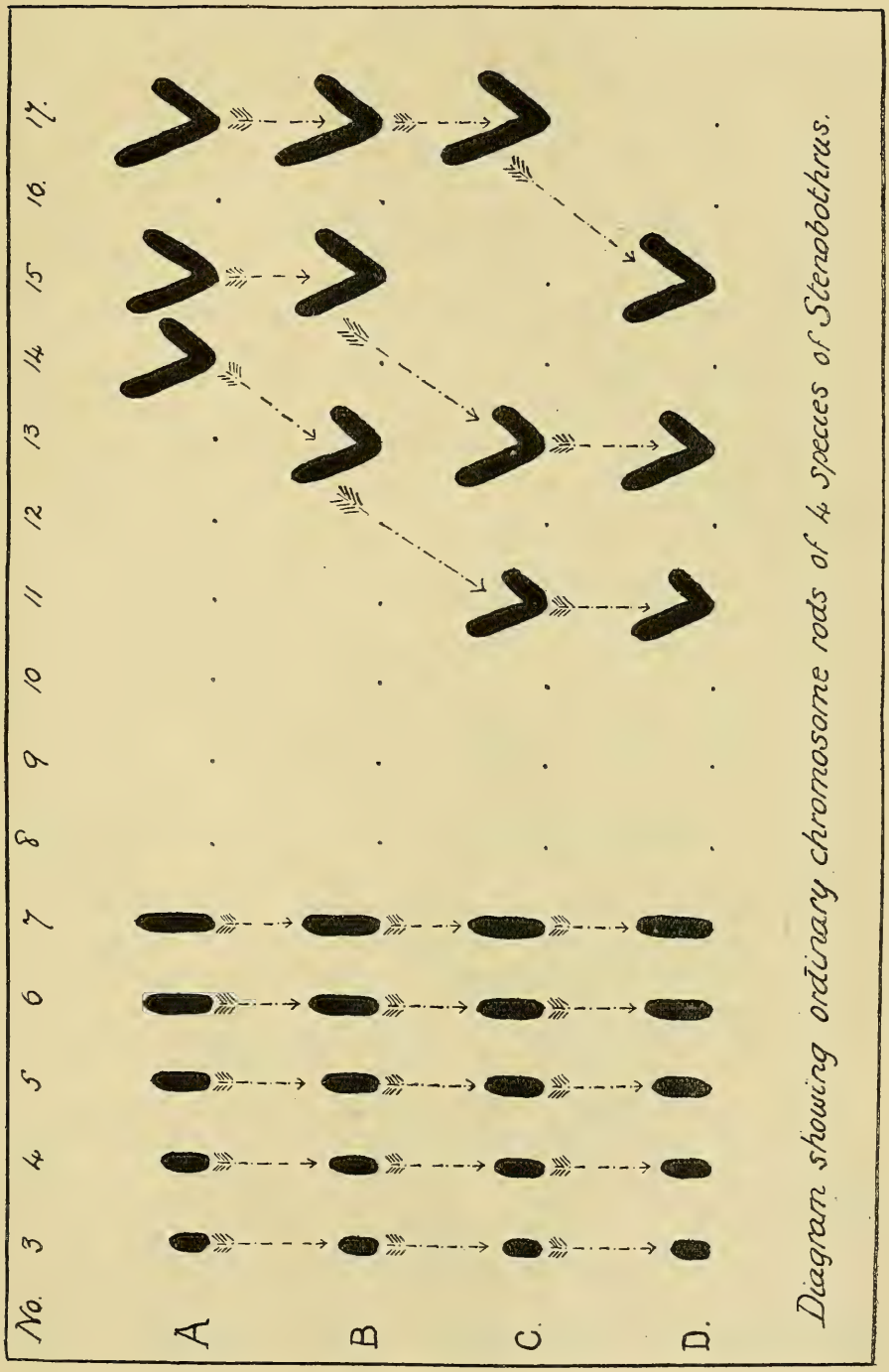


Fig. 6.

A, *Stenobothrus parallelus*. B, *S. viridulus*. C, *S. bicolor*. D, *S. cuvipennis*.

The second and alternative hypothesis postulates a continuous linear growth of chromosomes in the course of phylogeny, and is based upon data that support direct correspondence between the degree of somatic complexity of an organism and the total volume of its germ-cell chromatin; it moreover offers a logical explanation of the evolution of various rod-lengths. The measurements that I have given can be only approximations, and the difference between terms of the general series is probably smaller than that shown, but these measurements suffice to prove differences between complexes of allied species; and it is only reasonable to suppose that such differences are of comparatively recent origin and have evolved by some continuous process accompanying the somatic differentiation of the species. In certain cases the process may have been complicated by degeneration, possibly resulting in the complete disappearance of a particular chromosome from the complex, but, even if this additional factor is eventually established, I am aware of no reasons for discarding the assumption that the guiding principle in complex formation is and has been a purely linear growth of component rods.

I have already pointed out that if this second hypothesis is subsequently proved, morphological identity of chromosomes can be no guide to functional identity outside the narrowest limits of our classification; but in the case of allied species, which must have evolved along almost parallel lines, we may reasonably hope to establish correlation of individual chromosomes of the respective complexes, and thus form a basis upon which to attempt correlation of rod lengths and definite somatic characters,

Let us therefore consider again the complexes of these four species of *Stenobothrus*. The lengths of the five short chromosomes are the same in all cases, and their identities appear consequently to be established; the three long chromosomes, however, are not the same in any two complexes, and correspondence is therefore not at once apparent. If we accept the first hypothesis, which postulates invariable correspondence between definite rod-lengths and definite sets of somatic characters, we must realize that no long chromosome is common to all four species; Chromosome 11 is absent in *S. parallelus* and *S. viridulus*, Chromosome 13 is absent in *S. parallelus*, Chromosome 14 is absent in *S. viridulus*, *S. bicolor*, and *S. curtipennis*, Chromosome 15 is absent in *S. bicolor*, and Chromosome 17 is absent in *S. curtipennis*. If, on the other hand, we accept the second hypothesis, which postulates continuous linear growth of rods, we must realize that in these complexes the short, medium, and long chromosomes of the three are probably respectively identical. Thus Chromosome 13 of *S. viridulus* does not correspond with Chromosome 13 of *S. bicolor* and *S. curtipennis*, but corresponds with Chromosome 11 of the two latter and with Chromosome 14 of *S. parallelus*, for these chromosomes constitute the shortest member of the long group in each case; similarly, Chromosome 17 of *S. parallelus*,

S. viridulus, and *S. bicolor* is not unrepresented in *S. curtipennis*, but is functionally identical with Chromosome 15, which has not yet grown sufficiently in the last-named to be classed in the higher category. Correspondence between the remaining long chromosomes can be seen in the diagram by following the arrows, which have been inserted to show identities in all cases.

If the difference between terms of the general series is eventually found to be smaller than half the rod diameter, chromosomes that we now class as consecutive must be separated by intermediate lengths, and those that we class together may, as a result of more accurate means of measurement, be shown to have minutely differing lengths: this, however, cannot affect the three long chromosomes of *Stenobothrus*, for their respective lengths are such that mistake in identification is impossible. We must nevertheless remember that the correspondence indicated by the arrows is based upon a pure hypothesis, and that at present we possess no direct evidence in support of this correspondence.

Turning now to the consideration of somatic characters, we find that these grasshoppers are individually distinguished by slight but clearly defined differences. The following descriptions give the principal characteristics and are quoted from the works of Bolivar, Burr, and Kirby.

STENOBOTHRUS PARALLELUS.

1. Very variable in colour.
2. Antennæ longer in male than in female.
3. Pronotum with transverse furrow nearer to posterior than to anterior border.
4. Lateral carinæ of pronotum almost parallel or slightly approximating about the middle.
5. Elytra do not reach end of abdomen in male; in female do not reach beyond fourth abdominal segment.
6. Mediastinal area of elytra extended abruptly towards the apex and extended round base, forming a rounded lobule; anterior margin of elytra convex round base.
7. Wings rudimentary.
8. Length of body, male 14–15 mm., female 18–21 mm.

STENOBOTHRUS VIRIDULUS.

1. Green varied with darker.
2. Antennæ longer in male than in female.
3. Pronotum with transverse furrow midway between anterior and posterior borders.
4. Lateral carinæ of pronotum slightly angled near anterior border, rounded slightly posteriorly.

5. Elytra fully developed in both sexes.
6. Mediastinal area of elytra gradually extended towards the apex, prolonged to length of anterior border and not lobulate at base. Anterior border straight.
7. Wings developed.
8. Length of body, male 13–15 mm., female 20–24 mm.

Stenobothrus bicolor.

1. Very variable in colour.
2. Antennæ of equal length in both sexes.
3. Pronotum with transverse furrow nearer to anterior than to posterior border.
4. Lateral carinæ of pronotum sharply angled in anterior part, diverging towards anterior and posterior borders.
5. Elytra fully developed in both sexes.
6. Mediastinal area of elytra extended abruptly towards the apex and extended round base, forming a rounded lobule ; anterior margin of elytra convex round base.
7. Wings developed.
8. Length of body, male 15–16 mm., female 19–24 mm.

Stenobothrus curtipennis.

1. Variable in colour.
2. Antennæ longer in male than in female.
3. Pronotum with transverse furrow nearly in middle.
4. Lateral carinæ of pronotum straight and parallel.
5. Elytra very short.
6. Mediastinal area of elytra extended abruptly towards the apex and extended round base, forming a rounded lobule ; anterior margin of elytra convex round base.
7. Wings very short in female ; in male equal in length to body.
8. Length of body, male 17·5 mm., female 17·5 mm.

Let us now try to correlate these characters and the chromosome rod-lengths of the respective complexes. We will firstly consider the lateral carinæ of the pronotum ; these are parallel or slightly approximating in *S. parallelus*, *S. viridulus*, and *S. curtipennis*, but sharply angled in *S. bicolor*. This characteristic is distinctive, for Burr has pointed out that by it alone we can distinguish the last-named from the other three species. Now if correlation is evident, we must expect to find corresponding chromosomes of the same length in *S. parallelus*, *S. viridulus*, and *S. curtipennis*, but of a different length in *S. bicolor* ; if, however, we follow the arrows in the diagram we see that no long chromosome fulfils these conditions, and correlation is therefore not established.

Taking as a second example the mediastinal area of the elytra, we must expect to find corresponding chromosomes of the same length in *S. parallelus*, *S. bicolor*, and *S. curtipennis* and of a different length in *S. viridulus*, for in the three first named the area extends abruptly towards the apex whereas in the last it extends gradually. We again fail to observe such a chromosome ; and the same absence of correlation is noticeable with respect to the other characters on the list with the exception of colour, which is variable and untrustworthy.

Moreover, we are not more successful if we assume the first hypothesis, which postulates unchanging rod-lengths. Disregarding the arrows in the diagram and considering correspondence to depend entirely upon length, we find that the length of antennæ and angle of the lateral carinæ may be correlated with Chromosome 15 in *S. parallelus*, *S. viridulus*, and *S. curtipennis* ; but the fact that no other characteristics appear to correspond with chromosome lengths makes justification for this assumption doubtful. Furthermore, the genus *Stenobothrus* has been divided by Bolivar and other systematists into subgenera, and these species are now classified as follows :— *Chorthippus parallelus*, *Chorthippus curtipennis*, *Ornocestus viridulus*, and *Stauroderus bicolor* : it is noteworthy that the two whose complexes show the greatest differences in rod-lengths should thus be classed together.

Four explanations may be put forward to account for this failure. Firstly, we may assume that my measurements are inaccurate ; this, however, seems unlikely, for great care has been exercised, and the lengths of the long chromosomes are such that relative error should be impossible. Secondly, we may assume that the lengths of the five short chromosomes are not respectively identical in all the species ; in this case the characters mentioned may be correlated with these and not with the three long chromosomes : if, however, the principal somatic differences, upon which systematists have based their classification, are not traceable to obvious differences in long chromosomes, why should they be traceable to imperceptible differences in short chromosomes, and, if they are so traceable, to what are the obvious differences in the former due ? Thirdly, the arrows may be misleading : Chromosome 17 of *S. parallelus*, *S. viridulus*, and *S. bicolor* may, for example, correspond in *S. curtipennis* with Chromosome 13 and not 15, in which case the last named chromosome corresponds with the medium instead of the longest member of the three, and is accordingly functionally identical with Chromosome 15 of *S. parallelus* and *S. viridulus* and Chromosome 13 of *S. bicolor*. This is undoubtedly possible, if rods are continuously increasing in length, for a long chromosome may in the course of evolution be overtaken and passed by one that was shorter, and the latter may consequently be mistaken for the former : if this occurs, we must realize that measurements cannot always be a trustworthy index to functional correspondence even in the most closely allied organisms. Lastly, if the

chromosomes of a complex are qualitatively different, as we have reasons for believing, each must be concerned with a definite set of characters : difference in length of two corresponding chromosomes may therefore be connected with differences in several characters, and, even if the character under consideration is included in these, other factors are equally bound up in the chromatin rod, and may be responsible for apparently irreconcilable lengths.

In the circumstances I am inclined to think that the fourth explanation, possibly coupled with the third, will eventually be found to account for our present failure. It is difficult to believe that the obvious somatic differences mentioned in our list are not in some way connected with the lengths of the three long chromosomes, but until a thorough analysis has been made of both internal and external characteristics of these species we cannot hope to correlate somatic characters and chromosome rod-lengths in the genus. In 1908 McClung indicated a course of investigation upon Acridiidæ to be carried out upon these lines, but I have seen no paper by him on the subject : possibly he and his followers have been able to throw some light upon this difficult problem.

Resumé.

Each ordinary spermatogonial and secondary spermatocyte chromosome of *S. curtipennis* is composed of two equal rods, and each primary spermotocyte chromosome of four. The diameter of these rods is invariably ·83 μ and consequently lends further support to the assumption that the chromatin thread-width is constant in all organisms above and including Nemathelminthia.

The lengths of the ordinary rods constitute members of a general series in arithmetical progression ; the five short chromosomes are respectively identical with those of other members of the genus, but the lengths of the three long chromosomes once more enable the species to be identified.

A comparison between *S. parallelus*, *S. viridulus*, *S. bicolor*, and *S. curtipennis* fails to establish correlation of somatic characters and chromosome rod-lengths, but we have reason for believing that the obvious characteristics upon which identification is based are in some way connected with the three long chromosomes : our present failure is probably due to ignorance of the less obvious somatic characteristics and to the lack of trustworthy methods of identifying corresponding chromosomes in the respective complexes.

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Freshwater Rhizopoda and Heliozoa from the States of New York, New Jersey, and Georgia, U.S.A.; with Supplemental Note on Seychelles Species.

By G. H. Wailes, F.L.S.

(Plate 12.)

[Read 18th April, 1912.]

The Freshwater Rhizopoda of the States of New York and New Jersey have received little attention since the publication of Leidy's work in 1879, and I am not aware of any records from the State of Georgia. Since 1879 the number of described species of Rhizopoda has been more than doubled, and an investigation at the present time of the localities in which Leidy worked cannot fail to give fruitful results.

The records here given were obtained from gatherings made in the autumn of 1911 from the following localities :—

(1) Georgia.—Augusta, gathering of water-plants collected by D. K. Dalgish, Sept. 30th.

(2) New Jersey.—Lakehurst, gatherings from dry and submerged sphagnum and from the Lake, Sept. 18th ; also dried sphagnum purchased from New York florists, exact locality unknown.

(3) New York District.—Mainland. Split Rock Lake, N.J., Sept. 9th ; Boonton, N.J., Canal and River, Sept. 9th ; Van Cortlandt and Bronx Parks, N. York City, Sept. and Oct.

(4) New York State.—Long Island, gathering from Good Ground per R. Wendell Squires, Dec. 5th. Gathering made by myself, Dec. 16th to 19th, at Good Ground from Penney's Pond, Trout Pond, Old House Pond, and a small pond at the head of Smith's Creek *.

* Penney's Pond is about 3 miles N. of Good Ground ; Trout Pond is about 5 miles N.W. of Good Ground on the Riverhead Road ; Old House Pond is about 2 miles W. of Penney's Pond. All these ponds are about one-eighth of a mile in diameter.

Of Rhizopoda 161 species and varieties are recorded from the above localities, including five new species and ten new varieties; about forty are, I believe, now for the first time recorded from the United States. Four species of Heliozoa are also recorded.

In addition *Nebela tropica*, sp. nov., from Borneo, and *Euglypha cristata* var. *acicularis*, var. nov., from the British Isles, are also described, as they illustrate the affinities of some United States species.

The general results regarding distribution may be briefly summed up: the Rhizopod fauna was rich both in number of species and individuals, the majority of the species (say 80 per cent.) were similar to those found in Europe; the remainder consisted of: (1) species not uncommon in North America but more or less rare in Europe; (2) species or varieties which, so far as we know at present, are peculiar to America; (3) species in which considerable "local" variation or peculiarities occurred.

Some species of Rhizopoda may be peculiar to Europe, or common there and rare in America, but sufficient American data are lacking to enable any definite pronouncement to be made on this subject.

Slides containing specimens of the new species and varieties described in this paper have been given to the New York Museum of Natural History, where they are available for inspection.

The dimensions given ($\mu = \cdot 001$ mm.) are of the specimens from the above-named localities, except in the tabulated list of the genus *Euglypha*.

I have to thank Dr. E. Penard for his assistance and for his kindness in sending me mounted specimens from portions of some of the gatherings which were sent to him.

	Augusta, Georgia.	New Jersey.	New York District (mainland).	Long Island, N.Y.
	1	2	3	4
Class SARCODINA.				
Sub-Class **RHIZOPODA.**				
Order AMŒBINA.				
Family Lobosa.				
Amœba fluida, *Gruber*	..	×	..	..
„ guttula, *Duj.*	..	..	×	..
„ limax, *Duj.*	..	×	×	×
„ proteus (*Pallas*), *Leidy*	×	×	×	×
„ striata, *Penard*	×	..	..	×
„ verrucosa, *Ehrenb.*	..	×	..	×
„ vespertilio, *Pen.*	×	..	×	×
Dactylosphærium radiosum, *Bütschli*	×	..	×	..
Order CONCHULINA.				
Family Arcellida.				
Arcella angulosa, *Perty*	..	×	×	..
„ arenaria, *Greeff*	..	..	..	×
„ artocrea, *Leidy*	×	×	..	×
„ dentata, *Ehrenb.*	..	..	..	×
„ discoides, *Ehrenb.*	×	×	×	×
„ hemisphærica, *Perty*	..	×	..	×
„ mitrata, *Leidy*	..	×	..	×
„ polypora, *Pen.*	?	..	×	..
„ vulgaris, *Ehrenb.*	..	×	×	×
„ „ *var.* compressa, *Cash*	..	×	×	×
„ „ *var.* gibbosa (*Pen.*), *West*	..	×	×	×
Pseudochlamys patella, *Clap. et Lachm.*	..	×	×	..
Corycia flava, *Greeff*, sp.	×	×	×	..
Bullinula indica, *Pen.*	..	×	..	×
Centropyxis aculeata (*Ehrenb.*), *Stein*	×	×	×	×
„ „ *var.* discoides, *Ehrenb.*	..	..	×	..
„ „ *var.* ecornis (*Ehrenb.*), *Leidy*	..	..	×	×
„ „ *var.* spinosa, *Cash*	..	×	×	×
„ lævigata, *Pen.*	..	×	×	×
Plagiopyxis callida, *Pen.*	..	×	×	..
Family Difflugina.				
Difflugia acuminata, *Ehrenb.*	..	..	..	×
„ „ *var.* inflata, *Pen.*	..	..	×	×
„ amphoralis, *Hopk.*	×	×	×	..
„ arcula, *Leidy*	..	×	..	×
„ bacillariarum, *Perty*	×	×	..	..
„ „ *var.* elegans (*Pen.*), *Cash*	..	×	..	..
„ „ *var.* teres (*Pen.*), *Cash*	..	..	..	×

	Augusta, Georgia.	New Jersey.	New York District (mainland).	Long Island, N.Y.
	1	2	3	4
Family Difflugina (*cont.*).				
Difflugia bacillifera, *Pen.*	..	×	..	..
„ brevicolla, *Cash*	..	×	..	×
„ constricta (*Ehrenb.*), *Leidy*	×	×	×	×
„ corona, *Wallich*	..	..	×	×
„ globulus (*Ehrenb.*), *Hopk.*	×	×	×	×
„ gramen, *Pen.*	..	..	×	×
„ Leidyi, sp. nov.	..	×	..	..
„ limnetica, *Levander*	..	..	×	×
„ lobostoma, *Leidy*	×	..	×	×
„ lucida, *Pen.*	..	×	×	..
„ oblonga, *Ehrenb.*	..	×	×	×
„ „ *var.* cornuta, *Leidy*	..	×	..	..
„ „ *var.* lacustris (*Pen.*), *Cash*	..	×	×	×
„ „ *var.* nodosa, *Leidy*	..	×	..	..
„ „ *var.* venusta (*Pen.*), *Cash*	..	×	..	..
„ oviformis, *Cash*	×	..	×	×
Penardi, *Hopk.*	..	×	..	..
pristis, *Pen.*	×	..	×	×
„ pulex, *Pen.*	×	×	..	..
„ rubescens, *Pen.*	..	×	..	×
„ tuberculata (*Wallich*), *Archer*	×	..	×	×
„ „ *var.* minor, *Pen.*	×	..	×	×
„ urceolata, *Carter*	..	..	..	×
Cucurbitella mespiliformis, *Pen.*	..	..	×	..
Pontigulasia compressa (*Carter*), *Cash*	..	..	×	×
„ vas (*Leidy*), *Schout.*	..	..	..	×
Lesquereusia modesta, *Rhumbl.*	×	×	×	×
„ spiralis, *Bütschli*	×	×	..	×
Phryganella hemispherica, *Pen.*	..	×	×	×
„ nidulus, *Pen.*	..	×	..	×
Trigonopyxis arcula (*Leidy*), *Pen.*, *vide* Difflugia arcula	..	..	..	..
Cryptodifflugia compressa, *Pen.*	..	..	..	×
„ eboracensis, *Wailes*	..	..	..	×
„ oviformis, *Pen.*	..	×	..	×
Family Nebelina.				
Hyalosphenia elegans, *Leidy*	..	×	..	×
„ papilio, *Leidy*	..	×	..	×
„ subflava, *Cash*	..	×	..	×
Nebela americana, *Taránek*	..	×	..	×
„ „ *var.* falcata, var. nov.	..	..	..	×
„ ansata, *Leidy*	..	×	..	..
„ barbata, *Leidy*	..	×	..	×
„ carinata (*Archer*), *Leidy*	..	×	..	×
„ caudata, *Leidy*	..	..	..	×
„ collaris (*Ehrenb.*), *Leidy*	..	×	×	×
„ „ *var.* retorta, *Leidy*	..	..	..	×
„ cratera, sp. nov.	..	×	..	..
„ dentistoma, *Pen.*	×	×	..	×

	1	2	3	4
Family Nebelina (*cont.*).				
Nebela dentistoma, *var.* lacustris, var. nov.	×	×	×	..
„ equicalceus, *Leidy*	..	..	..	×
„ flabellulum, *Leidy*	..	×	..	..
„ galeata, *Pen.*	..	×	..	×
„ gracilis, *Pen.*	..	×	..	×
„ griseola, *Pen.*	..	×	..	..
„ longicollis, *Pen.*	..	×	..	×
„ marginata, *Pen.*	..	×	..	..
„ militaris, *Pen.*	..	×	×	×
„ minor, *Pen.*	..	×	..	..
„ parvula, *Cash*	..	×	×	..
„ scutellata, sp. nov.	..	×	..	..
„ tenella, *Pen.*	..	×	..	×
„ tincta (*Leidy*), *Awer.*	..	×	×	×
„ tubulata, *Brown*	..	×	..	×
„ tubulosa, *Pen.*	..	×	..	×
„ vitræa, *Pen.*	..	×	..	..
„ „ *var.* sphagni (v. note)	..	×	..	×
Quadrula symmetrica (*Wallich*), *F. E. Schulze*	..	×	..	×
„ „ *var.* irregularis, *Pen.*	..	×	..	×
„ „ *var.* curvata, var. nov.	..	..	..	×
Heleopera nodosa, sp. nov.	..	×	..	..
„ petricola, *Leidy*	..	×	..	×
„ „ *var.* major, *Cash*	..	×	..	..
„ „ *var.* amethystea, *Pen.*	..	×	..	×
„ rosea, *Pen.*	..	×	..	×
„ sordida, *Pen.*	..	×	..	..
„ sphagni (*Leidy*), *Hopk.*	..	×	..	×
„ „ *var.* lævis, var. nov.	..	×	..	..
„ sylvatica, *Pen.*	..	×	×	..
Awerinzewia cyclostoma (*Pen.*), *Schouteden*	..	..	..	×
Cochliopodium bilimbosum (*Greeff*), *Calkins*	..	×	..	..
Family Euglyphina.				
Euglypha alveolata, *Duj.*	×	×	×	×
„ „ *var.* cirrata, var. nov.	..	×	×	..
„ armata, *Wailes*	×	×	×	×
„ „ *var.* brevispina, *Pen.*	×	×	×	..
„ „ *var.* flexuosa, *Pen.*	×	..	×	..
„ brachiata, *Leidy*	..	×	..	..
„ „ *var.* librata, var. nov.	..	×	..	..
„ ciliata, *Ehrenb.*	..	×	×	×
„ „ f. glabra	..	..	×	..
„ „ f. heterospina	..	×	..	..
„ compressa, *Carter*	..	×	..	×
„ „ f. glabra	..	×	×	×
„ cristata, *Leidy*	..	×	×	×
„ „ *var.* major, *Wailes*	..	×	..	×
„ crenulata, sp. nov.	×	×	×	×
„ „ *var.* minor, var. nov.	..	..	..	×
„ filifera, *Pen.*	..	×	..	×
„ „ *var.* spinosa, var. nov.	..	×	..	..
„ lævis, *Perty*	..	×	×	×
„ mucronata, *Leidy*	..	×	..	..
„ strigosa (*Ehrenb*), *Leidy*	..	×	×	×
„ „ f. glabra	..	×	×	×
„ „ f. heterospina	..	×	..	..
„ „ *var.* muscorum, *Wailes*	..	×	×	..
„ rotunda, *Wailes*	..	×	×	×

	Augusta, Georgia.	New Jersey.	New York District (mainland).	Long Island, N.Y.
	1	2	3	4
Family Euglyphina (*cont.*).				
Placocysta spinosa, *Leidy*	..	×	..	..
,, ,, *var.* setigera, var. nov.	..	×	..	..
Assulina muscorum, *Greeff*	..	×	×	×
,, seminulum, *Leidy*	..	×	..	..
Cyphoderia ampulla (*Ehrenb.*), *Leidy*	..	..	×	..
,, trochus, *var.* amphoralis, *Wailes*	..	..	×	×
Trinema complanatum, *Pen.*	..	×	×	×
,, enchelys (*Ehrenb.*), *Leidy*	×	×	×	×
,, lineare, *Pen.*	×	×	×	×
Corythion dubium, *Taránek*	..	×	×	×
,, pulchellum. *Pen.*	..	×	..	..
Sphenoderia dentata, *Pen.*	×	×	×	×
,, lenta, *Schlumb.*	..	×	×	×
,, macrolepis, *Leidy*	..	×	..	×
Campascus minutus, *Pen.*	..	..	×	..
Family Gromiina.				
Pamphagus hyalinus, *Ehrenb.*? sp.	×	..	×	×
Pseudodifflugia Archeri, *Pen.* sp.	×	×	..	..
,, fulva, *Archer*	×	×	..	..
,, gracilis, *Schlumb.*	×	..	..	×
Family Amphistomina.				
Amphitrema flavum (*Archer*), *Pen.*	..	×	..	..
,, stenostoma, *Nüsslin*	..	×	..	..
,, Wrightianum, *Archer*	..	×	..	..
Sub-Class HELIOZOA.				
Order APHROTHORACA.				
Family Actinophryidæ.				
Actinophrys sol, *Ehrenb.*	..	×	×	×
Order CHALAROTHORACA.				
Family Acanthocystidæ.				
Acanthocystis turfacea, *Carter*	..	×	×	×
Order DESMOTHORACA.				
Family Clathrulinidæ.				
Clathrulina Cienkowskii (*Meresch.*), *Pen.*	..	×	..	..
,, elegans, *Cienk.*	..	×	×	..

List of Rhizopoda of which illustrations are given by Leidy (30) which have since received specific names.

	Plate.	Figures.
Amœba striata, *Pen.*	3.	37.
Arcella hemisphærica, *Perty*	27.	4, 15.
„ polypora, *Pen.*	28.	22.
„ vulgaris *var.* compressa (*Cash*)	28.	4–7.
Assulina muscorum, *Greeff*	37.	15–17, 26.
Centropyxis lævigata, *Pen.*	18.	37–44.
Corythion dubium, *Taránek*	39.	12, 13.
Cyphoderia ampulla *var.* papillata, *Wailes*	34.	5–8.
Difflugia acuminata *var.* inflata, *Pen.*	12, 13.	24; 2, 5, 8, 10.
„ amphora, *Leidy*	14, 16.	3, 4, 8; 34.
„ amphoralis, *Hopk.*	16.	33.
„ bacillariarum *var.* elegans (*Pen.*), *Cash.*	13.	23–26.
„ gramen, *Pen.*	15.	15.
„ hydrostatica, *Zach.*?	15.	27, 28.
„ lanceolata, *Pen.*	10.	17.
„ Leidyi, sp. nov.	16.	36.
„ oblonga *var.* atricolor, *Pen.*	10.	27.
„ „ *var.* claviformis, *Pen.*	10, 13.	16; 3, 4.
„ Penardi, *Hopk.*	15.	25, 26.
„ rubescens, *Pen.*	10.	24, 25.
„ tuberculata (*Wallich*), *Archer*	15.	16–19, 21, 22.
„ vescidula, *Pen.*	16.	37.
Euglypha alveolata *var.* cirrata, var. nov.	35.	5, 9.
„ armata, *Wailes*	35.	7, 8, 10.
„ brachiata *var.* librata, var. nov.	37.	7.
„ compressa, *Carter*	36, 37.	1–6; 29.
„ „ f. glabra	36.	23.
„ crenulata, sp. nov.	35.	2, 3, 4, 6, 15–18.
„ filifera, *Pen.*	36, 37.	7, 11–14; 28.
„ „ *var.* spinosa, var. nov.	35.	19?
„ strigosa *var.* muscorum, *Wailes*	36.	18.
Heleopera nodosa, sp. nov.	26.	12, 15, 20.
Lesquereusia modesta, *Rhumbl.*	19.	23.
Nebela americana, *Taránek*	23.	7.
„ dentistoma, *Pen.*	24.	12.
„ „ ? *var.* lacustris, var. nov.	24.	11.
„ galeata, *Pen.*	23.	2, 3.
„ gracilis, *Pen.*	23.	4–6.
„ marginata, *Pen.*	24.	6, 8.
„ militaris, *Pen.*	20.	18.
„ minor, *Pen.*	22.	11, 12, 16.
„ scutellata, sp. nov.	24.	25.
„ tubulata, *Brown*	24.	18.
Phryganella hemispherica, *Pen.*	16.	23, 24.
„ nidulus, *Pen.*	16.	1–4.
Pontigulasia vas (*Leidy*), *Schout.*	12.	2–9.
Trinema complanatum, *Pen.*	39.	41, 47, 61–63, 67, 68.
„ lineare, *Pen.*	39.	24, 38, 43, 55–59, 65.

List of the species recorded from New Jersey by Leidy (30) which were not found by the writer :—

Rhizopoda.

Amœba nobilis, *Pen.* (Ouramœba).
Amphizonella violacea, *Greeff.*
Biomyxa vagans, *Leidy.*
Cochliopodium vestitum, *Archer.*
Dinamœba mirabilis, *Leidy.*
Gromia fluviatilis, *Duj.*
Hyalodiscus rubicundus, *Hertw. & Less.*
Pamphagus mutabilis, *Bailey.*
„ granulatus, *F. E. Sch.*
Pellomyxa villosa, *Leidy.*
Vampyrella lateritia (*Fres.*), *Leidy.*

Heliozoa.

Actinosphærium Eichorni, *Ehrenb.*
Elœorhanis cincta, *Greeff.*
Heterophrys myriapoda, *Archer.*
Pompholyxophrys punicea, *Archer.*
Raphidiophrys elegans, *Hertw. & Less.*
„ viridis, *Archer.*

Synonyms for some of the species described by Leidy (30, 10, 36) :—

Amœba radiosa, *Ehrenb.*	now	Dactylosphærium radiosum, *Bütschli.*
Difflugia compressa, *Carter.*	„	Difflugia oblonga *var.* nodosa, *Leidy.*
„ cornuta, *Leidy.*	„	„ oblonga *var.* cornuta, *Leidy.*
„ globularis, *Leidy.*	„	„ globulus (*Ehrenb.*), *Hopk.*
„ globulosa, *Leidy.*	„	„ do. do.
„ nodosa, *Leidy.*	„	„ oblonga *var.* nodosa, *Leidy.*
„ pyriformis, *Perty.*	„	„ oblonga, *Ehrenb.* (10).
„ spiralis, *Ehrenb.*	„	Lesquereusia spiralis (*Ehrenb.*), *Bütschli.*
„ vas, *Leidy.*	„	Pontigulasia vas (*Leidy*), *Schout.*
Hyalosphenia tincta, *Leidy.*	„	Nebela tincta (*Leidy*), *Awer.*
Pamphagus avidus, *Leidy.*	„	Pamphagus granulatus, *F. E. Sch.*
„ curvus, *Leidy.*	„	do. do.

Heliozoa.

Acanthocystis chætopora, *Leidy*	now	A. turfacea, *Archer.*
Hyalolampe fenestrata, *Greeff.*	„	Pompholyxophrys punicea, *Archer.*

(Penard, Les Héliozoaires, 1904.)

According to Penard *Diplophrys Archeri*, pl. 45. figs. 7, 8, should be identified as *Elœorhanis cincta*, Greeff. Also *Ouramœba butulicauda* and *O. vorax* are no dombt *Amœba nobilis*, Penard (36. Les Héliozoaires, 1904).

List of Rhizopoda and Heliozoa found in New York City drinking-water, supplied from the Croton Reservoir during the autumn of 1911 :—

Rhizopoda.

Arcella discoides.
„ vulgaris.
„ vulgaris *var.* gibbosa.
Assulina seminulum.
Centropyxis aculeata.
„ aculeata *var.* discoides.
Campascus minutus.
Corythion pulchellum.
Cyphoderia ampulla.
„ trochus *var.* amphoralis.
Difflugia acuminata.
„ constricta.
Difflugia elegans.
„ gramen.
Euglypha alveolata.
„ ciliata.
Nebela collaris.
Plagiopyxis callida.
Phryganella hemispherica.
Trinema lineare.

Heliozoa.

Acanthocystis turfacea.
Actinophrys sol.

Order AMŒBINA.

The species recorded belonging to this Order consist almost entirely of the genus *Amœba*: they are local in their occurrence, in some places plentiful, in others scarce, but this may be in part due to the method of collection, which was not directed particularly to insure their capture; no very large individuals were seen, and many of the small ones had the appearance of being immature and their identity was doubtful.

[Cockerell (12, 1911) records this genus as *Amiba*-(*vide* Stiles & Hassall, Bureau of Animal Industr., U.S. Dept. Agric., Bull. 79, 1905, p. 38).]

Order CONCHULINA.

Genus Arcella, *Ehrenberg*.

Nine species and two varieties are recorded in this genus; the limits of some of the species are somewhat vague and may include forms which are entitled to specific or varietal names. The life-histories of some of the forms are required to clear up doubtful points. A general tendency for the apertures to become crenulate was observed.

Arcella angulosa, *Perty*.

A. vulgaris var. *angulosa*, Leidy, pl. 28. figs. 8–13 (30).
A. costata (Ehrenb.), Penard (36).

Not common, and sometimes closely approaching forms of *A. mitrata*. Diameter 84–100 μ; aperture about $\frac{1}{3}$ diameter.

A. arenaria, *Greeff*.

A. microstoma, Pen.
A. aureola, Maggi.

Recorded from Good Ground only: diameter about 80 μ; aperture $\frac{1}{3}$ diameter.

Distribution. Long Island, N.Y.; Canada (39); Colorado (35).

A. artocrea, *Leidy*.

(30) pl. 30. figs. 1–9.

Often numerous: in one individual the pores around the aperture were occupied by nodules or buttons 2·5 μ in diameter and projecting internally 1·75 μ (Pl. 12. fig. 1).

Diameter 120–230 μ; aperture 23–47 μ; height 50–63 μ.

Two individuals from Augusta, Ga., had apertures 65 μ diameter.

A. dentata, *Ehrenberg*.

A. stellaris, Perty.
Leidy, pl. 30. figs. 10–19 (30).

This is a scarce species and is recorded only from Good Ground, where it occurs in a small pond at the head of Smith's Creek.

The processes are usually nine in number, occasionally twelve ; the various forms depicted by Leidy were found, except those with a flattened crown.

Diameter 120–135 μ ; aperture 35–40 μ.

Distribution. Long Island, N.Y.; New Jersey (30); Pennsylvania (30); Michigan (41) ; Ohio (28).

Arcella discoides, *Ehrenberg.*

Leidy, pl. 28. figs. 14–21, 23–29 (30).

Generally distributed but not very numerous.

Size variable, but usually 130–160 μ in diameter ; aperture 60–80 μ ; height about one-third of the diameter.

An individual from Lakehurst was similar to Leidy's fig. 21 : diameter 52 μ ; height 17 μ.

A. hemisphærica, *Perty* (36).

A. vulgaris, Ehrenb. pars, Cash (10).

Not common ; diameter 42–50 μ.

A. mitrata, *Leidy.*

Leidy, pl. 29. figs. 1–24 (30).

Abundant in sphagnum, especially at Lakehurst. The structure of the test is similar to that of *A. vulgaris*, but the alveoli (0·8 μ diam.) are surrounded by six small pores (?) making a pattern similar to that on one form of *Cyphoderia* (*vide* 45. pl. ii. fig. 10 *b*) ; Cushman & Henderson (18) give microphotographs of it.

Diameter 70–176 μ ; aperture 22–50 μ; base 50–120 μ ; height 55–150 μ.

The test may be circular or polygonal ; the aperture may be with or without a secondary invagination and it may be circular or crenulate ; there appears to be no interdependence among these variations.

A. polypora, *Penard* (36).

Leidy, pl. 28. fig. 22 (30).

Not uncommon in Split Rock Lake and Van Cortlandt Park ; the largest individuals probably belong to a distinct species.

Diameter 230–340 μ ; aperture 126–190 μ.

A. vulgaris, *Ehrenberg.*

Leidy, pl. 27. figs. 1–3, 5–14, 17, 20–22 (30).

This species is not very plentiful ; the test consists of a chitinous envelope stiffened externally by bars 0·8 μ apart, disposed in three parallel rows inclined at 60° from each other. This structure is described by Penard (36) ; Cushman & Henderson (18) give microphotographs of it. As in the case of

A. mitrata, there is a superficial resemblance to the pattern on the tests of some forms of *Cyphoderia ampulla* (*vide* **45**. pl. ii. fig. 10 *d*).

Diameter 80–157 μ ; aperture 18–35 μ.

Var. GIBBOSA (*Pen.*), *West*.

A. vulgaris pars, Leidy, pl. 27. figs. 16, 23–35 (**30**).

Generally distributed but never numerous. Diameter 50–82 μ.

Var. COMPRESSA, *Cash* (**10**).

A. artocrea, Penard (**36**).

A. vulgaris pars, Leidy, pl. 28. figs. 4–7 (**30**).

Not common, but of normal size ; about 120 μ in diameter.

Genus PSEUDOCHLAMYS, *Clap. & Lachm.*

Cockerell (**12**, 1911) names this genus *Microchlamys*, the name *Pseudochlamys* having been previously used for a beetle (Zool. Anzeiger, xxxviii. Nr. 5/6, 15. 8. 1911).

Genus CORYCIA, *Dujardin*.

CORYCIA FLAVA, *Greeff*.

Not numerous but generally distributed ; usually found in mosses. Diameter 60–80 μ.

Distribution. Georgia ; New Jersey ; New York ; Canada (**39**).

[Cockerell puts forward "*Microcoryia*" as a name for this genus for reasons stated in Zool. Anzeiger, Bd. xxxviii. Nr. 5/6, 15. 8. 1911.]

Genus BULLINULA, *Penard*.

BULLINULA INDICA, *Pen.* (emend.) J. Roy. Micr. Soc. 1907.

Found in sphagnum but not common.

Diameter usually about 160 μ ; an individual at Lakehurst measured : length 225 μ, breadth 190 μ, aperture 87 μ.

Distribution. New Jersey ; Long Island, N.Y. : Canada (**39**).

Genus PLAGIOPYXIS, *Penard*.

PLAGIOPYXIS CALLIDA, *Pen.* (**37**, 1910).

This species has a world-wide distribution, but is easily overlooked owing to its having the appearance of a spheroidal form of *Difflugia constricta* or some other species with a similarly shaped test, but a careful examination of the aperture, which is often difficult to locate, will reveal its identity. Diameter 90–110 μ.

Distribution. Switzerland (*Penard*) ; British Isles (**45**) ; New Zealand ; Australia ; British Columbia (**39**) ; Borneo,

Genus Difflugia, *Leclerc.*

This genus is well represented both in species and numbers of individuals; one new species, *D. Leidyi*, is recorded.

Difflugia arcula, *Leidy.*

Leidy, pl. 15. figs. 34–37; pl. 16. figs. 30, 31 (30).

This species, which is in an anomalous position among the *Difflugiæ*, has been removed by Penard to the genus *Trigonopyxis*, gen. nov.; in future it should be known as *T. arcula* (Leidy), Penard (Rev. Suisse Zool. 1912).

It is abundant in sphagnum and damp mosses.

Diameter 70–140 μ.

D. bacillariarum, *Perty.* Var. elegans (*Pen.*), *Cash* (10).

D. acuminata pars, Leidy, pl. 13. figs. 23–26 (30).

On Pl. 12. figs. 2 & 3 is shown a form which is abundant at Lakehurst. The test is almost entirely composed of diatom frustules; in broad view it is two-horned, in narrow side view it appears normal.

Length 110–130 μ; breadth 95–105 μ; aperture about 35 μ.

D. Leidyi, sp. nov. (Pl. 12. figs. 4 & 5.)

Leidy, pl. 16. fig. 36 (30).

Test of medium size, composed of siliceous particles with an admixture of vegetable materials and sometimes of diatoms, circular or subcircular in transverse section: the fundus furnished with two (rarely three) horns arranged symmetrically in one plane; aperture circular, bordered by small siliceous grains. Plasma and pseudopodia normal.

Length, not including horns, 100–110 μ; breadth of body 78–80 μ; neck 35–40 μ in diameter; horns 30–40 μ in length.

Habitat. Submerged sphagnum.

Distribution. New Jersey.

Leidy (30) illustrates a test of typical form, the only one he observed; at Lakehurst it is not very rare.

D. oblonga var. cornuta, *Leidy.*

Leidy, pl. 12. figs. 17, 18 (30).

An individual of this variety found at Lakehurst measured: length (including horn) 240 μ, breadth 120 μ, aperture 32 μ, with a single horn 50 μ in length. Leidy's fig. 18 represents it very accurately, with the exception of the horn, which is smaller than on the Lakehurst specimen.

D. OVIFORMIS, *Cash* (10).

Numerous in Van Cortlandt Park and Long Island, with apertures evenly three- and four-lobed (45).

Habitat. Ponds and lakes.

Length 70–80 μ.

D. cratera, Leidy, represented by empty tests, is plentiful at Lakehurst and in New York City water-supply, but Leidy's supposition is undoubtedly correct that it is a *Ciliate* allied to the genus *Tintinnus*, probably *Codonella lacustris*, Entz.

Genus CUCURBITELLA, *Penard* (36).

CUCURBITELLA MESPILIFORMIS, *Penard* (36).

D. lobostoma pars, Leidy, pl. 15. fig. 7 (30).

Occurs in Van Cortlandt Park, but is rare ; this, however, may be due to the method of collecting ; in a pond in Yorkshire it was not seen, although numerous gatherings had been made, until during a drought it was found plentifully in the muddy sediment.

Length about 100 μ; diameter 80 μ.

It has been found in the Western States by Edmondson (private letter).

Genus CRYPTODIFFLUGIA, *Penard* (36).

CRYPTODIFFLUGIA EBORACENSIS, *Wailes* (45).

Found only in Penney's and Trout Ponds, Good Ground, where it is not uncommon in sphagnum. Many were seen in an active state. Colour reddish brown.

Length 26–28 μ; breadth 14–16 μ ; thickness 12–14 μ ; aperture 5–6 μ.

Distribution. Long Island, N.Y.; Alaska ; Great Britain (45).

C. COMPRESSA, *Penard* (36).

Only two individuals were seen in sphagnum, and they were unusually small. The pseudopodia were not observed.

Length 13 μ ; breadth 9 μ; thickness 5 μ.

Trout Pond, Good Ground.

C. OVIFORMIS, *Penard.*

Not common : some of the tests were noticeably compressed.

Length 14–20 μ ; breadth 10–14 μ ; aperture 3–4 μ ; nucleus 3·5 μ in diameter with a central nucleole.

Distribution. Lakehurst, N.J.; Good Ground, L.I.

Genus NEBELA, *Leidy.*

In the localities visited which were devoid of sphagnum few species or individuals of this genus are to be found, but in the Cedar Swamps of

Lakehurst, N.J., and around the ponds near Good Ground, L.I., the sphagnum is inhabited by many individuals and species; some species that are unknown or very rare in Europe are there quite numerous or not uncommon.

The following may be especially noted:—On Long Island are found *N. caudata* and *N. equicalceus*, the latter of a special form, also an interesting series of curved varieties of several species. At Lakehurst are found the three species with beaded apertures that form a compact group, viz. *N. tenella*, *N. griseola*, and *N. cratera*; also *N. ansata*; *N. vitræa* sp. ver., together with a variety having a test bearing curiously arranged angular plates, and *N. scutellata* inhabiting a test formed entirely of small quadrangular plates. In both localities are found *N. barbata*, *N. carinata*, *N. gracilis*, and *N. tubulata*.

Species which have been recorded from North America that were not observed were *N. bigibbosa*, *N. lageniformis*, and *N. vas* (39).

The numerous curved tests which are found at Penney's Pond, Good Ground, suggest many points of interest. In addition to *N. collaris* var. *retorta*, Leidy, two other species, *Nebela americana* and *Quadrula symmetrica*, are found there presenting the same modification; this variation must be of rare occurrence as Leidy records only a single test of this kind, and I am not aware of any other record: the association of so many in one limited habitat suggests that this form may be induced sporadically by certain local conditions.

Light is thrown on the question of the origin of the plates with which the *Nebelæ* construct their tests by the occurrence at Good Ground of the tests of *N. equicalceus* and *N. collaris* containing, and sometimes largely composed of, the scales of *Euglypha denticulata* var. *minor*, including even spines with the basal scales still attached; at Lakehurst, on the other hand, are found *N. scutellata* and forms of *N. vitræa* with tests composed of quadrangular or angular plates which can hardly have had a foreign origin.

NEBELA AMERICANA, *Taránek*.

Sitzber. böhm. Ges. Wiss. 1881; Abh. böhm. Ges. Wiss. xi. (1882), pl. 3. figs. 15, 16.

N. collaris pars, Leidy, pl. 23. fig. 7 (30).

N. americana, Cash & Hopk., pl. 31. figs. 15–18 (10); Penard, p. 363, figs. 4–6 (36).

The identification of this species presents certain difficulties. As first described by Taránek it is glabrous, not compressed, and intermediate in outline between *N. barbata*, Leidy, pl. 24. figs. 14–17, and figs. 18 & 19 (*N. tubulata*, Brown). The only *Nebela*, with which I am acquainted, answering to this description is *N. longicollis*, Pen., which is rare. A much more common species having a compressed test, wedge-shaped in broad view, has been generally accepted as the one which Taránek had under observation. To exchange the names now would only cause confusion and

serve no good purpose. I have, therefore, here recorded as *N. americana* a species answering to the following description: "Test wedge-shaped in broad view, rounded at the apex in narrow view, with a thickness equal to about two-thirds of the breadth and 120–175 μ in length," as illustrated by Cash & Hopkinson, pl. 31 (**10**).

Length 120–168 μ; breadth 60–90 μ; aperture 20–23 μ; thickness 40–50 μ.

Distribution. Absecom (*Leidy*) and Lakehurst, N.J.; Good Ground, Long Island.

Var. FALCATA, var. nov.

Many of the curved tests found in Penney's Pond, L.I., agree in size and structure with normal individuals of this species found there, but the specific characters are so modified that general characteristics must be relied on for their identification, and it is possible that the largest of these forms may be derived from *N. tubulosa*.

Length 130–170 μ.

N. ANSATA, *Leidy*.

Leidy, pl. 25. figs. 1–8 (**30**).

At Lakehurst not uncommon in submerged sphagnum.

Length 217–242 μ; breadth, of body 94–110 μ, over horns 130–160 μ; aperture 40–45 μ by 27–31 μ; thickness 60–70 μ.

N. BARBATA, *Leidy*.

Leidy, pl. 24. figs. 14–17 (**30**).

This species is distinguished from all other species of *Nebela* by the fine cilia scattered over the surface of the test; they are of uniform diameter, terminating in truncate ends, 10–18 μ in length, less than 0·5 μ in diameter. They are unaffected by cold sulphuric acid and become invisible in oil of cloves and in Canada balsam.

Length 112–126 μ; breadth 40–50 μ; aperture 12–17 μ; thickness 35–40 μ. At Good Ground one individual measured only, length 80 μ, breadth 35 μ, aperture 12 μ.

Distribution. Lakehurst; Absecom (*Leidy*), N.J.; Good Ground, Long Island; British Isles (**3**, **10**, **45**); Sierra Leone (coll. by Major Wailes).

N. CAUDATA, *Leidy*.

Leidy, pl. 26. figs. 21–24 (**30**).

Found in sphagnum on the borders of Trout Pond, Good Ground; it is rare and the proportion of living individuals observed was small; some have been kept alive in sphagnum during the winter, but up till the time of writing they have refused to become active.

Length 80–84 μ; breadth 60–68 μ; aperture 20 μ. Spines 4 or 3 in number and 16–20 μ in length.

Nucleus about 12 μ in diameter with a large nucleole.

Distribution. Long Island, N.Y.; Absecom, N.J. (*Leidy*); Nantucket Isl., Mass. (18); Ohio (28); British Columbia (39); Scotland (*Murray*); Ile Macquarie (39); New Zealand (39); Australia (39); Gough Isl. (*Penard*).

Nebela carinata (*Archer*), *Leidy*.

Leidy, pl. 24. figs. 1–5, 9, 10.

Often numerous in submerged sphagnum.

Length 200–260 μ; breadth 135–160 μ; aperture 30–40 μ; thickness 63–73 μ.

N. collaris (*Ehrenb.*), *Leidy*.

Leidy, pl. 22. figs. 1–10, 13–15, 17–20 (30).

Not abundant; length 100–130 μ.

Var. retorta, *Leidy*. (Pl. 12. figs. 6 & 7.)

Leidy, pp. 151, 289, fig. p. 151 (30).

Tests answering to Leidy's description and drawing are not uncommon in Penney's Pond, Good Ground, the only locality in which I found them. They are not merely curved tests but are modified to such an extent as to veil the specific characteristics. The curvature takes place in the plane of the greatest width and is generally greater than in Leidy's drawing (p. 151); in narrow view there is no curvature and the tests are compressed. The aperture, which is not notched, loses its smooth outline and is bordered by circular or oval plates.

Accompanying the *Nebelæ* was a similar form which could without hesitation be referred to *Quadrula symmetrica*, the typical form of which is numerous there. Two species of *Nebela* seem to be thus modified, viz. *N. collaris* and *N. americana*, and the latter in its typical form is much the more numerous. The occurrence together, in fair numbers and in a single limited habitat, of these special forms seems to indicate that local conditions have a controlling influence in their formation and that they are not autonomous species but sporadic varieties locally induced.

Length 130–170 μ; breadth 52–97 μ; aperture 26–39 μ. Leidy observed a single individual only, length 144 μ.

N. cratera, sp. nov. (Pl. 12. figs. 8 & 9.)

Test of moderate size, not compressed, pyriform, neck small and parallel; aperture bordered by a prominent collar semicircular in section. Plasma and pseudopodia normal.

Length 120–135 μ; diameter 74–80 μ; neck about 30 μ diameter and 30–35 μ in length. Aperture 25–35 μ in diameter; collar 30–40 μ in diameter.

Habitat. Submerged sphagnum.

Distribution. New Jersey.

This species belongs to the group of which *N. tenella* and *N. griseola* are the other members, but it exceeds them in size and is of quite distinctive shape. The test is formed of angular plates mixed with a few circular plates and diatoms; it is of a dark colour, more or less opaque, and is very fragile. It is circular in transverse section.

N. DENTISTOMA, *Penard.*

Leidy, pl. 24. fig. 12 (30).

Typical individuals of this species occur only sparingly, and varied in length from 90 μ to 110 μ, with a breadth equal to $\frac{2}{3}$–$\frac{3}{4}$ of the length. No circular or *N. flabellulum*-shaped tests were observed.

Var. LACUSTRIS, var. nov. (Pl. 12. fig. 10.)

? *N. collaris* pars, Leidy, pl. 24. fig. 11 (30).

Test large, pyriform, compressed, formed of angular siliceous plates and grains of various sizes; with a small neck and aperture broadly oval.

Length 120–206 μ; breadth 100–143 μ; aperture 25–45 μ; thickness 64–90 μ.

Distribution. Lakehurst, N.J.; Augusta, Ga.

This variety exceeds in size every other of the numerous forms of this species and appears to be a link with the large *N. vitræa*, Pen. sp. ver.; its size also distinguishes it from *N. scotica*, Brown (3. l. 78–82 μ).

The test illustrated by Leidy, pl. 24. fig. 11, taking as correct the given magnification ($\times 250$), measures 208 μ in length and 152 μ in breadth, which nearly agrees with the Lakehurst specimens: the given measurement of another, viz. length 100 μ, breadth 68 μ, is very like *N. scotica*, Brown, but the thickness given, 20 μ, seems improbable.

N. EQUICALCEUS, *Leidy* (31, 1874).

N. hippocrepis, Leidy (30), pl. 24. fig. 13; pl. 25. figs. 9–14.

This is a scarce species; it is found in Penney's Pond, Good Ground. Leidy illustrates two forms: one (pl. 25. figs. 9–14) provided with a solid carina extending around the fundus, the other (pl. 24. fig. 13) without this carina; only the latter of these two forms was seen. The development of the internal processes varied somewhat.

Dimensions. Length 203–235 μ; breadth 126–142 μ; aperture 38–45 μ; thickness 72–80 μ. Length of horns when well developed 35–60 μ.

The test is composed of plates of various shapes and sizes ; sometimes they are large, circular and imbricated, or they may be small and separated from each other. Some were found with tests largely composed of the scales of *Euglypha crenulata* var. *minor*, which were quite perfect and easily recognisable, as they differ slightly in shape from the scales of *E. crenulata*, a species not recorded from Good Ground (*vide* Pl. **12**. fig. 38).

NEBELA GRACILIS, *Penard* (**37**, 1910).

N. collaris pars, Leidy, pl. 23. figs. 4–6 (**30**).

N. galeata pars, Penard, p. 351, figs. 4, 5 (**36**).

Described only recently by Penard, this species is not uncommon at Lakehurst and Good Ground. Leidy represents it very faithfully in figs. 4 and 5 (length 110 μ), but in the end view fig. 6 the sides appear to have been crushed. usually they are flattened but not concave. At Lakehurst it is found in a very handsome form up to 130 μ in length ; at Good Ground it is of normal size, 97–110 μ in length.

Dimensions. Length 97–130 μ ; breadth 42–65 μ ; aperture 14–23 μ ; thickness 25–40 μ.

Habitat. Submerged sphagnum.

Distribution. Absecom (*Leidy*) and Lakehurst, N.J. ; Penney's Pond, Good Ground, L.I. ; Switzerland (*Penard*).

N. GRISEOLA, *Penard* (**39**).

Clare Island Survey, figs. 25 *a–g* (**45**).

This species, recently described by Penard from Australia and from Ireland, is found at Lakehurst in association with the two other species of *Nebela* possessing beaded apertures, *N. tenella*, Pen., and *N. cratera*, sp. nov.; usually larger than the former, at Lakehurst they are of nearly equal size, but can be distinguished from one another by the greater compression of the test of *N. tenella*.

Length 80–85 μ ; breadth 53–60 μ ; aperture 16–18 μ in diameter ; thickness 43–50 μ.

Distribution. Lakehurst, N.J. ; Australia (**39**) ; Ireland (**45**).

N. LONGICOLLIS, *Penard* (**34**).

This species is distinguished from *N. americana* by the slight compression of the test and the elongated neck. It is much smaller than *N. tubulosa* and of slighter proportions.

Length 133–140 μ ; breadth 45–52 μ ; aperture 20 μ ; thickness 40–48 μ.

Distribution. Colorado (**35**) ; New Jersey ; Switzerland (**36**) ; Australia, New Zealand (**39**).

At Lakehurst it is rare; it has a resemblance to *N. barbata*, Leidy, but is glabrous, more robust, and has a shorter neck.

N. MARGINATA, *Penard* (36).

N. carinata pars, Leidy, pl. 24. figs. 6–8 (30).

Not common, only a few individuals being found in sphagnum at Lakehurst. Length 150 μ; breadth 115 μ; aperture 40 μ.

N. MINOR, *Penard* (36).

N. collaris pars, Leidy, pl. 22. figs. 11, 12, 16 (30).

Found in New Jersey sphagnum. Length 80–90 μ.

N. MILITARIS, *Penard* (34).

Hyalosphenia tincta pars, Leidy, pl. 20. fig. 18 (30).

Generally distributed but not abundant. Length 65–80 μ.

N. PARVULA, *Cash* (10).

Found in dry sphagnum and moss. Length 74–84 μ.

N. TENELLA, *Penard*, 1893 (36).

This species is found in sphagnum and occurred numerously in a sample from New Jersey; the size was above normal and approached that of *N. griseola*, a species from which its greater compression serves to distinguish it.

Length 68–84 μ; breadth 45–60 μ; aperture 13–17 μ; thickness 30–39 μ; collar 20–28 μ in diameter.

N. SCUTELLATA, sp. nov. (Pl. 12. figs. 11 & 12.)

Quadrula symmetrica pars, Leidy, pl. 24. fig. 25 (30).

Test moderately large, hyaline, pyriform, compressed; composed of small siliceous, rectangular plates arranged in irregular rows, while smaller rectangular plates may be superimposed at the junctions of the larger plates; margin of aperture often irregular; plasma and pseudopodia normal; nucleus small with several nucleoles.

Length 120–135 μ; breadth 74–90 μ; aperture 24–30 μ; thickness nearly two-thirds of the breadth.

Habitat. Sphagnum and wet mosses.

Distribution. New Jersey; the Seychelles.

The test of this species resembles, in its possession of small superimposed plates, a form of *N. vitrea* which is found at Lakehurst and shown on Pl. 12. figs. 15–17; it also bears a great resemblance in structure to *N. tropica*, Pl. 12. figs. 13 & 14.

In the Seychelles (fig. 43) it is found without the small covering-plates, but having an admixture, usually 5 to 10 per cent., of circular discs in the composition of the tests.

It differs from *Quadrula symmetrica* both in shape and structure of the test.

Leidy's illustration is of an individual, length 140 μ, breadth 100 μ, aperture 30 μ.

NEBELA TINCTA (*Leidy*), *Awer.*

Hyalosphenia tincta, Leidy.
Nebela bursella, Taránek.
Nebela bohemica, Taránek.

Plentiful in all gatherings of sphagnum, but scarce in mosses. The limits of this species, both as regards size and form, are difficult to define. On the one hand it approaches *N. collaris*, and on the other *N. flabellulum*.

N. TROPICA, sp. nov. (Pl. **12**. figs. 13 & 14.)

Test of medium size, hyaline, pyriform, compressed; composed of rectangular siliceous plates; aperture dilated in broad view, with a shallow notch in narrow view.

Length 74–93 μ; breadth 45–60 μ; aperture 20–30 μ; thickness 30–35 μ.

Habitat. Moss.

Distribution. Borneo; Seychelles (fig. 44).

The arrangement of the plates forming the test is generally more regular near the fundus, where they are arranged diagonally, than near the aperture. In the outline of the test there is a close resemblance to *N. militaris*, but the structure and general appearance are very similar to those of *N. scutellata*, a species to which it is undoubtedly closely allied. For comparison with *Quadrula symmetrica*, figures of the latter are given on Pl. **12**. figs. 18, 19, 45. The moss in which this species was first found was collected at Sarawak, Borneo, by J. Brook.

N. TUBULATA, *Brown* (**3**).

Leidy, pl. 24. fig. 18 (**30**).

This is not uncommon in sphagnum; the form with a torulose neck is also frequent (**45**).

Length 56–78 μ; breadth 28–48 μ; aperture 10–15 μ; length of neck 18–32 μ.

Leidy's fig. 18 measures 80 μ in length, but fig. 19 of a similar test scales 250 μ at the stated magnification of $\times$ 100; this is probably a mistake for $\times$ 350, at which the test would measure 71 μ in length.

N. TUBULOSA, *Penard*.

Not abundant; at Good Ground the large proportion of quadrangular plates often present in the tests was a noticeable feature.

Length 174–196 μ; breadth 74–93 μ; aperture 30–35 μ.

At Lakehurst an abnormally large individual occurred, length 300 μ, breadth 150 μ, aperture 40 μ, the test principally composed of imbricated discs 6–12 μ in diameter; it may have been a case of plastogomy or double encystment.

N. VITRÆA, *Penard*. (Pl. **12**. figs. 15–17.)

Two individuals of large size similar to those, until now, known only from the deep Swiss Lakes, were found at Lakehurst; length 258 μ and 187 μ, breadth 135 μ and 130 μ, apertures 45 μ and 40 μ; they had tests composed of square and angular plates, with apertures bordered by 8 or 9 large grains.

The form usually found at Lakehurst is smaller, often with a curiously constructed test (figs. 15–17), in which circular plates predominate mixed with some angular or irregularly shaped plates, the interstices between them being re-enforced by small covering-plates somewhat similar to those figured by Penard (**36**. p. 272, fig. 4), and analogous to the ones found on the test of *N. scutellata*.

Length 115–155 μ; breadth 70–100 μ; aperture 23–31 μ.

The small sphagnum-inhabiting variety of normal type and about 100 μ in length, as illustrated by Cash & Hopkinson (**10**), is not common in the localities under investigation. As has been pointed out by Penard (**45**. p. 51 note), this form is intermediate in character between *N. vitræa*, sp. ver., and *N. dentistoma*, but further investigation and comparison of specimens from various localities are necessary in order to determine the limits of the various forms; they can be grouped, however, in a series of types which may be differentiated as *N. vitræa*, sp. ver., var. *minor* and var. *sphagni*; all of which occur in association at Lakehurst.

Genus QUADRULA, *F. E. Schulze*.

QUADRULA SYMMETRICA (*Wallich*), *F. E. Sch.* (Pl. **12**. figs. 18 & 19.)

Leidy, pl. 24. figs. 20–24 and p. 144 (**30**).

This species is certainly very distinct from *Q. irregularis* (*vide* Penard, **39**), and approaches the genus *Nebela* very closely, a relationship which is accentuated by a comparison with such species as *N. tropica* and *N. scutellata*.

Length 68–120 μ; breadth 45–74 μ; aperture 20–30 μ.

Distribution. Colorado (**35**); Massachusetts (**17**); New Hampshire (**19**); New Jersey! (**30**); New York! (**20**); Pennsylvania (**30**); British Columbia (**39**); Alaska.

Var. IRREGULARIS, *Penard.* (Pl. **12**. fig. 20.)

Less common than type and below the normal size.

Length 140 μ or under.

Var. CURVATA, var. nov. (Pl. **12**. fig. 21.)

Test as in the type, but curved as in *Cyphoderia*; aperture polygonal, formed by 6–7 plates.

Length 80–100 μ; breadth 33–45 μ; aperture 11–16 μ; thickness 25–28 μ.

Distribution. Penney's Pond, Good Ground.

Several living, but no active individuals were seen; the amount of curvature of the test is subject to variation.

[Cockerell (**12**, 1911) records this genus as *Quadrulella*, the name *Quadrula* being preoccupied in another Philum.]

Genus HELEOPERA, *Leidy.*

HELEOPERA NODOSA, sp. nov. (Pl. **12**. figs. 22–24.)

Heleopera petricola pars, Leidy, pl. 26. figs. 12, 15, 20.

Test large, elongate, slightly compressed, the ratio of the transverse axes being about 3 : 4; apex acute, terminated by a nodular mass of large quartz-grains; aperture bordered by slightly recurved lips; plasma and pseudopodia normal.

Length 152–213 μ; breadth 80–94 μ; thickness 60–75 μ; aperture 45–60 μ in width.

Habitat. Submerged sphagnum.

Distribution. Lakehurst, New Jersey.

Leidy (fig. 12) illustrates an individual of this species broader in proportion to its length than any of those found at Lakehurst. *H. nodosa* is distinguished from *H. petricola* by its greater size, its elongate form, the acute apex bearing a nodular mass of sand-grains, and its less compression; it bears no resemblance to any other species of *Heleopera*. At Lakehurst, N.J., it is not uncommon.

H. SPHAGNI (*Leidy*), *Hopk.* (**10**).

Difflugia (*Nebela*) *sphagni*, Leidy (1874) (**31**).
Heleopera picta, Leidy (1879) (**30**), pl. 26. figs. 1–11.

This species is very numerous in the Lakehurst sphagnum. Dimensions:—Length 116–155 μ; breadth 90–125 μ; thickness about half the breadth.

Var. LÆVIS, var. nov.

Dimensions. Length 63–95 μ; breadth 46–70 μ.
Habitat. Submerged sphagnum.
Distribution. Lakehurst, N.J.
This variety is distinguished from the type only by its small size, from *H. sordida* by its smooth test destitute of adherent particles. At Lakehurst it occurs plentifully in company with *H. sphagni*. Leidy does not give any illustration of this small variety.

H. PETRICOLA, *Leidy*.

Leidy, pl. 26. figs. 13, 14, 16–19 (30).

Abundant in sphagnum of a light brown colour; in lakes and ponds frequently colourless. Length 70–114 μ.

Var. MAJOR, *Cash* (10).

The larger individuals agree with Cash's description of this variety. Length 120–135 μ.

Var. AMETHYSTEA, *Penard*.

Not common, of normal size and colour.

H. ROSEA, *Penard*.

Not frequent except at Good Ground; the broader test and yellow lips as well as the rose colour differentiate it from the last species.

H. SORDIDA, *Penard* (37, 1910).

Not uncommon at Lakehurst and of normal size. Length 62–68 μ.

Genus AWERINZEWIA, *Schouteden*.

AWERINZEWIA CYCLOSTOMA (*Penard*), *Schout*.

This species is rare; in appearance it resembles *Heleopera petricola* var. *amethystea*, but it is larger and has opaque white plates or grains incorporated with its violet-coloured test; the aperture, which is small and oval, is bordered by an internal thickening of the test. Length about 150 μ.
Distribution. Switzerland (36); Ireland (45); Ontario (39); Seychelles.

Genus Euglypha, *Dujardin.*

The study of the American species of this genus has resulted in the addition of one new species and five new varieties, and a revision of the table of species published in the Clare Island Survey (**45**) is rendered necessary *.

Division I. *Spines when present always modified scales. Transverse section circular (except* E. bryophila) *and aperture circular.*

		Length.
1. E. aspera, *Pen.*	Scutiform scales; rough test.	150–170 μ
2. E. crenulata, *sp. nov.*	Denticulated scutiform scales; spines.	115–140 μ
Var. minor, *var. nov.*	Do. do. ; glabrous or spined.	80–110 μ
3. E. scutigera, *Pen.*	Scutiform scales; glabrous.	77– 88 μ
4. E. armata, *Wailes*	Oval scales; spines around apex.	55–100 μ
5. E. alveolata, *Duj.*	Circular or oval scales; glabrous.	45–100 μ
Var. minor, *Taránek*....	Do. do.	30– 45 μ
Var. cirrata, *var. nov.* ..	Short spines at apex.	65– 75 μ
6. E. mucronata, *Leidy*	Single or double spine at apex.	108–140 μ
7. E. cristata, *Leidy*	Spines in tuft at apex.	33– 71 μ
Var. major, *Wailes*	Glabrous.	60– 90 μ
Var. acicularis, *var. nov.*	Single or double spine at apex.	84– 94 μ
8. E. brachiata, *Leidy*.....	Lateral spines near aperture.	93–128 μ
Var. librata, *var. nov.* ..	Oar-shaped arms near middle of test.	100–104 μ
9. E. bryophila, *Brown*	Tuft of spines at apex; test slightly compressed.	35– 52 μ

Division II. *Spines, when present, always articulated.*

Section A. *Test compressed, aperture circular.*

10. E. filifera, *Penard*	Long spines in single or double rows.	55– 93 μ
Var. spinosa, *var. nov.* ..	Spines scattered over test.	60– 90 μ
11. E. strigosa (*Ehrenb.*) *Leidy*, *f.* glabra & heterospina.	Thickened aperture-scales. Spines.	45–100 μ
Var. muscorum, *Wailes*	Test wider than type; scales smaller.	50– 80 μ
12. E. rotunda, *Wailes*.....	Thin aperture-scales; glabrous.	22– 52 μ

Section B. *Test compressed, aperture oval.*

13. E. lævis, *Perty*	Undenticulate aperture-scales; glabrous. (May have subcircular section and aperture.)	22– 55 μ
14. E. ciliata, *Ehrenb.* spec., *f.* glabra & heterospina.	Thin denticulated aperture-scales; spines.	40– 90 μ
15. E. compressa, *Carter*, *f.* glabra.	Lenticular section; spines.	70–132 μ

* Instances are rare in which the identity of individuals of this genus is doubtful, provided the tests are in good condition and the specific characters can be clearly observed; tests slightly crushed (accidentally) are to be guarded against. Active individuals are the best for study, but in some species it may be necessary to isolate and treat them with sulphuric acid, first cold and dilute to dissolve the plasma, and then with concentrated acid and boiled to dryness to disintegrate the test into its elements.

EUGLYPHA ALVEOLATA, *Duj.*

Leidy, pl. 35. fig. 14 (30).

Under this name Leidy includes a whole group of species, and subsequent American workers have followed his classification and have generally failed to specify which of the various forms illustrated by Leidy they have found. In gatherings from over 40 counties in the British Isles no spined form of *E. alveolata* was seen by me, but in the United States a form occurs which is undoubtedly *E. alveolata*, and is furnished with one or two short scale-spines at or near the apex ; the presence of these scale-spines shows that this species is a member of the group of *Euglyphæ* belonging to Division I. in the table, and is quite distinct from species that bear articulated spines. It may also be pointed out that it is only among the species belonging to Division I. that two rows of denticulated aperture-scales are present. The following is the description of *E. alveolata* :—

Test of medium size, elongate oviform ; not compressed, glabrous. Body-scales circular to broadly oval. Aperture circular, bordered, generally, by two rows of finely denticulated scales, 8–12 in each row. Nucleus 10–15 μ diam., with a single nucleole. Pseudopodia few, long, and radiating.

Dimensions. Length 45–100 μ ; breadth about half the length ; aperture 0·4 to 0·5 of the breadth.

Var. MINOR, *Taránek* *.

Similar to the type but smaller. Length 30–45 μ.

The body-scales are oval ; it is much less common than the type.

Var. CIRRATA, var. nov. (Pl. 12. figs. 25–27.)

E. alveolata pars, Leidy, pl. 35. figs. 5, 9 (30).

Test as in the type, but the fundus furnished with one or two short scale-spines; aperture usually bordered by two rows of denticulated scales. Nucleus and pseudopodia normal.

Length 60–75 μ ; diameter 0·46–0·5 length ; aperture 13–14 μ ; spines 10–17 μ in length.

Distribution. Split Rock Lake, N.J. ; Pennsylvania (*Leidy*).

In the United States the breadth of this variety, and also of the type, is generally less than half the length of the test, whereas in Europe it is generally more than equal to half the length. Two pairs of this variety were seen in conjunction, and in both cases the individuals of each pair were similar.

* Sitzungsb. böhm. Ges. der Wiss. 1881, p. 233 (1882).

Euglypha brachiata, *Leidy* (31). (Pl. 12. figs. 28 & 30.)

Leidy, pl. 37. figs. 5, 6, 8–10 (30).

This species has from two to six tapering spines arising from scales in one or more of the first three rows of scales adjoining the aperture; rarely, a second series is also present (*vide* Leidy, pl. 37. fig. 6); the distance between their origin and the aperture usually varies from 10–20 μ; the spines are from 50–65 μ long and 2 μ in diameter at the base, tapering to a point. Those found by Penard at Vancouver (39) had the spines modified into flat ribbon-like appendages (fig. 30 *b*), and one found at Lakehurst also had the spines flattened to 3 μ wide and 1 μ thick with thickened extremities (figs. 30 *c*, *c'*).

Dimensions. Length 87–123 μ; diameter 28–39 μ; aperture 19–13 μ.

Habitat. Submerged sphagnum.

Distribution. New Jersey! (*Leidy*); Roan Mountains, Va. (*Leidy*, 30); Wales and Ireland (*G. S. West*, J. Linn. Soc., Zool. xxviii. p. 328, 1901); British Columbia (*Penard*, 39).

Var. librata, var. nov. (Pl. 12. figs. 29 & 30 *a*.)

E. brachiata pars, Leidy, pl. 37. fig. 7 (30).

Test as in the type, but furnished with two to four lateral appendages arising from near the centre of the sides, their free ends widened into oar-like blades. Nucleus and pseudopodia normal.

Length 100–104 μ; diameter 32–35 μ; aperture 13 μ; arms 35–38 μ long, 1 μ diameter, widening to 2·5 μ at the extremities.

Habitat. Submerged sphagnum.

Distribution. New Jersey! (*Leidy*); Roan Mountains, Va. (*Leidy*)?

Much less common than *E. brachiata*, of which at least twenty were seen for each one of var. *librata*; also less variable in size and number of arms, which generally consist of two only.

E. cristata, *Leidy* (31).

Leidy, pl. 37. figs. 1–4 (30).

This species, found in moss and in lakes and ponds, varies between the following dimensions:—Length 34–70 μ; breadth 12–24 μ: aperture 5–9 μ. With an average size of:—Length 40–50 μ; breadth 14–17 μ. Only one or two individuals above or below these limits were found; the tuft of spines at the apex is sometimes absent.

Var. major, *Wailes* (45). (Pl. 12. fig. 31.)

The test of this variety is generally larger than the type, less contracted towards the aperture, and usually devoid of spines. The plasma and pseudopodia are normal. Length 60–90 μ; diameter 20–30 μ; aperture 10–14 μ.

Distribution. Lakehurst, N.J.; Long Island, N.Y.; Scotland (Orkney Islands) (**46**); Ireland (Mayo) (**45**).

Those found at Lakehurst measured from 70–90 μ in length and are broader than the British variety; those found at Good Ground, Long Island, were 60–70 μ in length and smaller than the British.

Var. ACICULARIS, var. nov.* (Pl. **12**. figs. 32 & 33.)

Test larger than in the type, the fundus rather more acute and furnished with either one or two erect spines, which may be flexuous; the spines when solitary often coinciding with the longitudinal axis of the test; plasma and pseudopodia normal.

Length 84–94 μ; diameter 23–24 μ; aperture 12–14 μ; spines 23–42 μ in length.

Habitat. Submerged sphagnum.

Distribution. Clare Island, Mayo; Inishbofin, Galway: Ireland (**45**) *.

The spines of *E. mucronata*, Leidy, originate in scales at the extreme apex of the test, which is prolonged into a sharp cone, whilst in the variety under consideration the scales furnishing the spines are below the apical scales and the flexure necessary in order to bring a spine coincident with the axis of the test is a little distance above its base.

EUGLYPHA CRENULATA, sp. nov. (Pl. **12**. figs. 34–37.)

E. alveolata pars, Leidy, pl. 35. figs. 2, 3, 4, 15–18 (**30**).

Test large, not compressed, either elongate-oviform or with sides tapering from the hemispherical fundus in nearly straight lines to the aperture. Fundus furnished with 2–6 stout scale-spines arising at nearly equal distances from the apex. Aperture circular and bordered by two rows of finely denticulated scales, 12–14 in each row. The body-scales scutiform, with crenulated lower margins. Nucleus large, placed posteriorly; pseudopodia normal.

Length 115–140 μ; diameter 67–77 μ. Aperture 25–30 μ. Length of spines 20–50 μ. Body-scales 10–12 μ long. Nucleus about 35 μ in diameter.

Habitat. Submerged sphagnum, lakes, ponds, &c.

Distribution. New Jersey! (*Leidy*); New York State, Long Island; Pennsylvania (*Leidy*).

Distinguishing features. Is distinguished from *E. scutigera* and *E. armata* by its crenulated scutiform body-scales and its greater size; from *E. aspera* by its smooth test and usually smaller size.

Remarks. This species appears to be represented by Leidy, pl. 35. figs. 2, 3, 6, 15–18, but the lower margins of the scales are not shown even in fig. 18; the form represented by his fig. 3 is perhaps the most common, at any rate in

* The Roy. Irish Acad. Report No. 65 of the Clare Island Survey was in the press when this variety was found and its description could not be included in that paper (*op. cit.* pp. 40 and 62, notes).

some localities. These tests, when empty, are characterised by the peculiar optical effect of the small circles formed by the imbrication of the scales at their upper and lower edges ; in living individuals the outlines of the scales are obscured from view by the plasma.

The form of the spines is subject to the same variation as in *E. armata* : they may be either (*a*) short and truncate, (*b*) short and pointed, (*c*) long and straight, or (*d*) long and flexuous ; they are sometimes incurved. Tests destitute of spines are occasionally found.

Leidy, pl. 35. fig. 2, shows an individual 160 μ in length (none were seen by me over 140 μ), but it may represent a double-sized encystment test.

Var. MINOR, var. nov. (Pl. **12**. fig. 38.)

Test similar to type, but smaller and usually destitute of spines.

Length 80–110 μ ; breadth 45–64 μ ; aperture 16–20 μ.

Habitat. Lakes and ponds.

Distribution. Split Rock Lake, N.J., and Long Island, N.Y.

Is usually glabrous, but when provided with spines only distinguished from *E. armata* by the shape of the body-scales.

The body-scales are somewhat different in shape from those of the type ; they are shown in fig. 38. When incorporated in the tests of *Nebela collaris* and *N. equicalceus* they are displayed with perfect distinctness, and can be observed even better than when artificially isolated. These scales are generally 11–12 μ in length, but the width varies according to the position they occupy on the test, those centrally placed being the widest.

EUGLYPHA FILIFERA, *Pen.* (**34**).

E. ciliata pars, Leidy, pl. 36. figs. 7, 11–14 ; pl. 37. fig. 28.

The test of this species as found in Europe is oviform in shape, and the spines are distributed at regular intervals in a single row ; the compression of the test is slight, the ratio of the transverse axes not exceeding 4 : 5. In the United States the following forms are found :—

(*a*) Test similar to European type (Leidy, pl. 36. fig. 7).

(*b*) The spines are duplicated and arranged in a double row or rarely irregularly (Leidy, pl. 36. figs. 11–13).

(*c*) The test is constricted near the aperture and is more compressed, the ratio of the transverse axes being 2 : 3 (Leidy, pl. 36. fig. 14).

(*d*) The test is of typical form but sparsely covered with scattered spines— var. *spinosa*, var. nov.

The forms (*a*) and (*b*) occur at Lakehurst and at Good Ground, L.I. Dimensions : Length 73–93 μ ; breadth 30–42 μ ; aperture 10–15 μ. Transverse section from subcircular to a ratio of axes of 4 : 5. Spines 20–30 μ long.

Form (*c*) is found at Good Ground, L.I. Dimensions : Length 48–58 μ ; breadth 24–29 μ; aperture 7–10 μ ; thickness two-thirds of the breadth. Spines 18–26 μ long, arranged in a single row.

Var. SPINOSA, var. nov. (Pl. 12. fig. 39.)

? *E. ciliata* var. *strigosa* pars, Leidy, pl. 35. fig. 19 (30).

Test like type, but furnished with spines sparsely scattered over the surface of the test. Plasma and pseudopodia normal.

Length 60–90 μ ; breadth 26–40 μ; aperture 10–15 μ ; thickness 0·8 to 0·9 μ. Spines 10–30 μ in length. Scales about 9·5 μ by 4·5 μ. Nucleus 12–14 μ in diameter.

Habitat. Submerged sphagnum.

Distribution. New Jersey ; Alabama (*Leidy*).

Like the type, this variety is distinguished from *E. alveolata* and all other species included in Div. I. of the Table of *Euglypha* by having articulated spines ; the slight compression of the test distinguishes it from other spine-bearing species included in Div. II.

E. MUCRONATA, *Leidy* (31, 1878).

Leidy, pl. 37. figs. 11–14 (30).

The individuals of this species recorded from Lakehurst (about half a dozen) agreed with Leidy's descriptions and illustrations ; none were observed in a state of activity. The following additional details may be added to Leidy's account of this species :—The aperture-scales are bluntly rounded, each having three crenulations in relief, which form low rounded projections beyond the edge ; the body-scales are oval, about 13 μ by 10 μ, becoming narrower towards the extremities of the test ; the spines are continuations of the terminal scale or scales, which are fitted together with great exactness ; just within the apex there may be a chitinous diaphragm ; the spines are flattened, measuring 2 μ by 1·25 μ near the base, 12–23 μ in length.

Length 100–130 μ (Leidy, 108–140 μ) ; diameter 37–43 μ (Leidy, 32–44 μ) ; aperture 15–20 μ ; spines 12–23 μ (Leidy, 20–44 μ).

Distribution. New Jersey ! (*Leidy*) ; Cape Horn (*Certes*).

E. STRIGOSA (*Ehrenb.*), *Leidy*.

E. ciliata var. *strigosa* pars, Leidy, pl. 35. fig. 20 (30).

In all the localities, as in Britain, this is the most numerous species ; it did not exceed in size those found in Europe, namely 45–100 μ in length. Owing to Leidy as a rule showing only one view of the tests which he illustrates, fig. 20 is the only one of this species about which there is no reasonable doubt. The characteristic features are a compressed test with a circular aperture, generally bordered by thickened aperture-scales.

Var. MUSCORUM, *Wailes* (45).

E. ciliata pars, Leidy, pl. 36. fig. 18 (30).

This variety, recently described, is generally found in moss or dry sphagnum. It may be spined, as shown by Leidy, pl. 36. fig. 18, or may be glabrous ; the width is greater in proportion to the length than in the type, and it is more compressed, but the aperture retains its circular shape ; the body-scales are smaller.

Distribution. United States, Panama, Peru, Europe.

Genus PLACOCYSTA, *Leidy.*

PLACOCYSTA SPINOSA (*Carter*), *Leidy.*

Leidy, pl. 38. figs. 1–16 (30).

Often numerous in sphagnum from New Jersey. Length 115–163 μ ; breadth 80–120 μ ; aperture 50–80 μ ; spines 20–35 μ in length, varying from linear to lanceolate in form.

Var. SETIGERA, var. nov. (Pl. 12. fig. 40.)

Test slightly smaller than the type, but otherwise similar; furnished with numerous long acicular spines scattered near the edges and arising at the imbrications of the scales. Plasma and pseudopodia normal.

Length 125–135 μ ; breadth 75–85 μ ; aperture 55–65 μ ; spines 25–45 μ in length.

Habitat. Sphagnum.

The disposition of the spines varies : they may be confined to the borders of the test, or be spread over its surface until only the central portions are glabrous ; none were found having the whole of the test covered with spines as in *P. jurassica*. Although larger than the smallest individuals of *P. spinosa*, the average size was decidedly less than that of the type.

Genus ASSULINA, *Ehrenberg.*

ASSULINA SEMINULUM, *Leidy.*

Leidy, pl. 37. figs. 18–25 (30).

Not plentiful. Length 80–85 μ.

A. MUSCORUM, *Greeff.*

A. minor, Penard (36).

A. seminulum pars, Leidy, pl. 37. figs. 15–17, 26 (30).

Numerous and generally distributed. Length 40–50 μ.

Leidy includes this species with the former, but the difference in size is usually sufficient to distinguish them.

Genus Cyphoderia, *Schlumberger*.

Cyphoderia ampulla (*Ehrenb.*), *Schlumb.*

C. margaritacea, Schlumb.
Leidy, pl. 34. figs. 1–16 (30).

Small and rather scarce, found only in the lakes and larger ponds; it is found in the New York City water-supply.

Length 95–110 μ. Leidy gives the length as 110–200 μ; in the British Isles the limits are 61–190 μ (45).

Distribution. North America. British Columbia (39), Colorado (35), Florida (30), Iowa (21), New Jersey (30), Michigan (41), New York (20), Nova Scotia (30), Pennsylvania (30), Rhode Island (30), Wyoming (30).

C. trochus var. amphoralis, *Wailes* (45).

Of similar form to the preceding, but the test is composed of imbricated plates instead of non-imbricated discs. Found in the same localities as the preceding; also in Long Island.

Length 110–120 μ. Limits in Britain, 87–153 μ (45).

A description and classification of this genus will be found in the Proc. Royal Irish Academy, 1911 (45), from which it will be seen that, in the absence of definite information as to the structure of the test (*i. e.* whether imbricated or not), drawings of individuals cannot be identified.

In the absence of this information some of Leidy's illustrations may represent *C. trochus* or one of its varieties; but taking for granted that all the tests are of the type shown in pl. 34. fig. 16 (30)—that is, are composed of round discs with a superficial hexagonal appearance—then figs. 5–8 represent *C. ampulla* var. *papillata*, Wailes (45), a variety which has been found in the Western States by Edmondson (private letter).

C. ampulla var. *major*, Pen., is also probably represented among Leidy's illustrations, but cannot be identified without details of the structure of the test (45).

Genus Campascus, *Leidy*.

Campascus minutus, *Penard*.

Occurs in the New York water-supply drawn from the Croton Lake Reservoir, which is situated about 30 miles north of the city.

This species has not been recorded previously from America. Length 64 μ; diameter 30 μ; aperture 10 μ.

Distribution. Switzerland (*Penard*); Loch Ness (*Penard*) and Hebrides, Scotland.

Genus Trinema, *Dujardin*.

Trinema complanatum, *Pen*.

T. enchelys pars, Leidy, pl. 39. figs. 41, 47, 48, 61, 62, 63, 67, 68 (30).

Not uncommon, but generally of small size. Length 25–55 μ.

T. enchelys, *Leidy*.

Leidy, pl. 39, pars (30).

Not numerous, and in some localities rare. Usually 40–70 μ in length, but a few individuals exceeded 100 μ (up to 105 μ). On pl. 39 Leidy depicts three species of *Trinema* and *Corythion dubium*, q. v.

T. lineare, *Penard*.

T. enchelys pars, Leidy, pl. 39. figs. 38, 43, 55–59, 65 (30).

Generally numerous. Length 20–32 μ.

Genus Corythion, *Taránek*.

Corythion dubium, *Taránek*.

T. enchelys pars, Leidy, pl. 39. figs. 12, 13 (30).

Generally distributed, but not very numerous.

Genus Sphenoderia, *Schlumb*.

Sphenoderia dentata, *Penard*.

S. lenta pars, Leidy, pl. 34. fig. 40 (30).

Numerous and above the average size. Length 50–60 μ; diameter 25–30 μ.

S. lenta, *Schlumb*.

Leidy, pl. 34. figs. 25–39, 41 (30).

Generally distributed, and in some localities numerous. Length 29–64 μ; breadth 17–50 μ; aperture 7–24 μ.

S. macrolepis, *Leidy* (30).

Rare, but widely distributed in sphagnum.

Length 30–32 μ.

Distribution. Malaga (*Leidy*); Lakehurst, N.J.; Long Island, N.Y.; British Isles (3) (45).

S. fissirostris, Pen., was not found and has not yet been recorded from America. Two of Leidy's illustrations (30. pl. 34. figs. 37, 38) may refer to this species, but seem rather to represent abnormal forms of *S. lenta*.

Genus AMPHITREMA, *Archer*.

Three species belonging to this genus are recorded from Lakehurst, N.J. None are numerous and all are of medium size. They have not been recorded previously from America.

AMPHITREMA FLAVUM (*Archer*), *Penard*.

Ditrema flavum, Archer.

Length 50–77 μ; breadth 37–42 μ; thickness 15–20 μ.

A. STENOSTOMA, *Nüsslin*.

Length 80 μ; breadth 60 μ; thickness 35 μ.

A. WRIGHTIANUM, *Archer*.

Length 50–63 μ; breadth 30–56 μ; thickness 15–30 μ.

HELIOZOA.

The four species recorded are not uncommon and are generally distributed.

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Supplemental Notes on Freshwater Rhizopoda from the Seychelles.

In January 1912 I received from Sergt. Godley, Overseer of Crown Lands, a gathering of moss and some sediment from a pool, collected in Mahé at the beginning of December 1911. Mahé is of granite formation, and contains few pools or lakes in which aquatic vegetation flourishes. The following list consists principally of moss-inhabiting species; considering the restricted habitat the list is a fairly long one. Forty species and three varieties are here recorded, of which two varieties are now described for the first time, namely :—

Nebela gracilis var. *stomata.*
Nebela lageniformis var. *minor.*

Two recently described species, *Nebela scutellata* and *N. tropica*, occur fairly numerously, and, curiously, in both species circular discs are mingled with the square plates which usually form the sole constituents of the tests. The presence of these discs confirms the propriety of placing these two species among the *Nebelæ.*

Few of the species occurred numerously, and most of the individuals were below the average size.

Class SARCODINA.

Sub-Class RHIZOPODA.

Order AMŒBINA.

Family Lobosa.

Genus Amœba.

Amœba verrucosa, *Ehrenberg.*

Syn. *A. terricola,* Greeff.

Owing to the exceptional powers of this species in resisting desiccation it was possible to identify one or two individuals.

Order CONCHULINA.

Family Arcellida.

Genus Arcella.

Arcella arenaria, *Greeff.*

Rare. Diameter 80–90 μ.

Genus Awerinzewia.

Awerinzewia cyclostoma (*Penard*), *Schouteden*.

Syn. *Heleopera cyclostoma*, Penard.

Not common. It is very similar in size and appearance to *Heleopera petricola* var. *amethystea*, Pen., but the aperture, instead of being linear and wide, is small and oval, and is surrounded by a more or less thickened internal border, the thickening taking place gradually on the inside of the test.

The test is noticeable for the opaque whitish plates scattered on a bright amethystine groundwork. The usual size is about 150 μ in length; those found here were rather small, measuring about 130 μ in length.

Genus Centropyxis.

Centropyxis aculeata, *Stein*.

Of this usually numerous species only one individual was observed.

C. arcelloides, *Penard*.

Several seen, about 70 μ in diameter.

C. lævigata, *Penard*.

Not common. Diameter 80–120 μ.

Genus Difflugia.

Difflugia arcula, *Leidy*.

Syn. *Trigonopyxis arcula* (Leidy), Penard, *q. v.*

D. constricta, *Leidy*.

Numerous. Length 50–90 μ.

D. oblonga, *Ehrenb*.

Syn. *D. pyriformis*, Perty.

Rare. Length 80–100 μ.

D. pristis, *Penard*.

Rare. Length 65 μ.

Genus Heleopera.

Heleopera sordida, *Penard*. (Rev. Suisse Zool. 1910.)

Below the average size, often with but few adherent particles on the crown of the test. Length 45–55 μ.

HELEOPERA SYLVATICA, *Penard*.

Rare. Length 70 μ.

Genus HYALOSPHENIA.

HYALOSPHENIA ELEGANS, *Leidy*.

Several seen. Length 80–85 μ.

H. SUBFLAVA, *Cash*.

Many were abnormally short and broad. Length 45-65 μ; breadth 30–45 μ.

Genus LESQUERUSIA.

LESQUERUSIA MODESTA, *Rhumbler*.

This is a pond form. Several seen, all about 80 μ in length; 62 μ in breadth; aperture 21 μ in diameter.

Genus NEBELA.

NEBELA COLLARIS, *Leidy*.

Not common and below the usual size. Length 95–110 μ.

N. GRACILIS, *Penard*. (Rev. Suisse Zool. 1910.)

Var. STOMATA, var. nov. (Pl. **12**. figs. 41 & 42.)

This variety differs from the type in the possession of two evaginated pores, one on either side of the neck. Similar protuberances occur on other *Nebelæ*, i. e. *N. tuberosa* and *N. americana*. Individuals also occur here of a more slender form than shown in figs. 41 & 42, with a long, slender neck; they are below the average size, measuring about 90 μ in length.

Length 90–130 μ; breadth about half the length or less; thickness two-thirds of the breadth; aperture oval, about 20 μ by 13 μ, slightly notched in narrow view.

Distribution. Peru (l. 107–130 μ); Long Island, U.S.A. (l. 100–116 μ).

N. LAGENIFORMIS, *Penard*.

Rare but quite typical. Length 120–130 μ.

Var. MINOR, var. nov.

A small form, which differs from the type in size only, is not uncommon; the individuals observed varied from 85–100 μ in length.

This variety is widely distributed, and is referred to in the report on the Rhizopoda of Clare Island *.

The torulose neck and usually larger size distinguish it from *N. tubulata*, Brown.

Length 77–100 μ.

Distribution. England * ; Ireland * ; Peru ; Australia (*Penard*) † ; Colorado, U.S.A.

Nebela militaris, *Penard*.

Not uncommon. Length 68–80 μ.

N. scutellata, *Wailes*. (Pl. 12. fig. 43.)

This species, first described in the present Journal, occurs here numerously but of rather small size ; the tests, as also those of *N. tropica*, are remarkable for the presence of small circular discs, which are mingled with the rectangular plates, usually the sole constituents of the test ; the discs vary in number from none to sixty or more in a single test, few tests having less than a dozen of them ; the square plates measured from 6–7 μ in width ; occasionally a few diatom frustules are also present. Several living individuals were seen, but none were active ; the plasma was of the normal type and crowded with food-particles ; the nucleus is small, about 7 μ in diameter, and contains several ill-defined nucleoles. No tests were found in which small covering-plates are present, such as occur in the United States.

Length 105–120 μ ; one abnormal individual measured, length 174 μ ; breadth 120 μ ; aperture 35 μ.

Distribution. United States.

N. tincta (*Leidy*), *Awerinzew*.

Rare. Length 100 μ.

N. tropica, *Wailes*. (*Vide* p. 140.) (Pl. 12. fig. 44.)

Not uncommon : as in the case of *N. scutella* the tests were remarkable for having numerous circular discs mingled with the quadrangular scales ; in other respects they were quite typical. It is worthy of note that these two recently described species, which in other localities are characterised by the rectangular scales which form the tests, should in this locality occur in association, and both have circular discs mingled with the square scales.

Length 70–75 μ.

Distribution. Borneo ; Peru.

* Wailes & Penard in Proc. Roy. Irish Acad. vol. xxxi. (1911). Clare Island Survey, pt. 65, pp. 48, 50, pl. 5. fig. 28 *a*, *b* (1911).

† Brit. Antarctic Exped., Biol. vol. i. pt. 6 (1911).

Nebela tubulata, *Brown*. (Journ. Linn. Soc., Zool. xxxii. (1911), p. 79.)
Several were seen. Length about 60 μ.

N. tubulosa, *Penard*.
Not uncommon. Length 175 μ.

Genus Phryganella.

Phryganella hemispherica, *Penard*.
Numerous, but no living individuals were observed. Diameter 30–60 μ.

Genus Plagiopyxis.

Plagiopyxis labiata, *Penard*. (Brit. Antarctic Exped., Biol. vol. i. pt. 6 (1911).)
Several were seen. Certain forms of *Difflugia constricta* approach this species very closely in the form of the test; a study of active individuals is desirable for ascertaining the exact relationships of this species. Diameter 55–80 μ.

Genus Quadrula.

Quadrula symmetrica, *F. E. Schulze*. (Pl. **12**. fig. 45.)
All the observed tests were of an elongated type; the larger scales varied from 8–10 μ in breadth. Length 84–90 μ.

Genus Trigonopyxis.

Trigonopyxis arcula (*Leidy*), *Penard*.

Syn. *Difflugia arcula*, Leidy, Rhiz. North Amer. 1879.
Trigonopyxis arcula, Penard, Revue Suisse Zool. 1912.

Occurs numerously. This Rhizopod, which occupied an anomalous position among the *Difflugiæ*, has been placed by Penard in a new genus. Diameter 80–135 μ; aperture regularly trilobed.

Family Euglyphina.

Genus Assulina.

Assulina muscorum, *Greeff*.
Numerous. Length 40–45 μ.

Genus Euglypha.

Euglypha alveolata, *Dujardin*.
Rare. Length about 60 μ.

Euglypha ciliata, *Ehrenberg.*
Not rare. Length 60–70 μ.

E. compressa, *Carter.*
A few seen. Length about 70 μ.

E. cristata, *Leidy.*
Not uncommon. Length 40–65 μ.

E. filifera, *Penard.*
Rare. Length 65 μ.

E. lævis, *Perty.*
Not uncommon. Length 22–40 μ.

E. rotunda, *Wailes.* (Proc. Roy. Irish Acad. vol. xxxi. pt. 75 (1911).)
Only one seen ; length 55 μ.

E. strigosa, *Leidy.*
Common. Length 60–70 μ.

Var. muscorum, *Wailes.*
Of average size : length 70 μ ; breadth 50 μ ; aperture 22 μ.

Genus Sphenoderia.

Sphenoderia dentata, *Penard.*
Not common. Length 48–50 μ.

Genus Trinema.

Trinema complanatum, *Penard.*
Not common. Length about 40 μ.

T. enchelys, *Leidy.*
Rare. Length 35–70 μ.

T. lineare, *Penard.*
Numerous but usually small : length 18–23 μ. A few abnormal individuals were observed, possessing long and narrow tests with large apertures : length 35–45 μ ; breadth 12–14 μ ; aperture 6–7 μ.

EXPLANATION OF PLATE 12.

Fig. 1. ARCELLA ARTOCREA, Leidy. Section of a test through the pores around the aperture, showing nodules projecting internally; × 2000. Lakehurst.

2, 3. DIFFLUGIA BACILLIARUM var. ELEGANS (Pen.), Cash; × 300. 2, Broad, and 3, narrow, side views of test. Lakehurst.

4, 5. DIFFLUGIA LEIDYI, sp. nov.; × 320. 4, Side view; 5, oral view. Lakehurst.

6, 7. NEBELA COLLARIS var. RETORTA, Leidy. 6, Test, × 310; 7, aperture, × 740. Penney's Pond, Good Ground, Long Island.

8, 9. NEBELA CRATERA, sp. nov. 8, Test, × 300; 9, aperture, × 800. Lakehurst.

10. NEBELA DENTISTOMA var. LACUSTRIS, var. nov.; × 250. Lakehurst.

11, 12. NEBELA SCUTELLATA, sp. nov. 11, Broad view of test, × 320; 12, portion of test, × 1000. Lakehurst.

13, 14. NEBELA TROPICA, sp. nov.; × 450. 13, Broad, 14, narrow, side views of test. Borneo.

15–17. NEBELA VITRÆA, Penard. 15, Broad side view of test, × 320; 16, 17, portions of test, × 1000. Lakehurst.

18, 19. QUADRULA SYMMETRICA (Wallich), F. E. Schulze; × 450. 18, Broad, 19, narrow, side views of test. New Jersey.

20. Do. do. var. IRREGULARIS, Pen.; × 450. Good Ground, Long Island.

21. Do. do. var. CURVATA, var. nov.; × 450. Penney's Pond, Good Ground, Long Island.

22, 23. HELEOPERA NODOSA, sp. nov.; × 320. 22, Broad, and 23, narrow, side views. Lakehurst.

24. Do. do. × 250. Broad side view of test. Lakehurst.

25–27. EUGLYPHA ALVEOLATA var. CIRRATA, var. nov. 25, Two individuals in conjunction; 26, 27, apices, showing varieties of spines, × 400. Split Rock Lake, New Jersey.

28. EUGLYPHA BRACHIATA, Leidy; × 400. Lakehurst.

29. Do. do. var. LIBRATA, var. nov.; × 400. Lakehurst.

30. Do. do. *a*, *a'*. Spine as seen from side and end views of a test; *b*. End view of a spine from Vancouver, British Columbia (after Penard, **39**); *c*, *c'*. Intermediate form of spine.

Do. do. var. LIBRATA. *d*, *d'*. Two views of a spine. Lakehurst. All × 500.

31. EUGLYPHA CRISTATA var. MAJOR, Wailes; ×400. Lakehurst.

32, 33. Do. do. var. ACICULARIS, var. nov. Apices and varieties of spines; × 700. Inishbofin, Ireland.

34–37. EUGLYPHA CRENULATA, sp. nov. 34, Active individual, × 400; 35, body-scale; 36, aperture-scale; 37, spine-scale. (). Augusta, Georgia.

38. Do. do. var. MINOR, var. nov. Body-scale; × 1000.

39. EUGLYPHA FILIFERA var. SPINOSA, var. nov.; × 320. Broad view of active individual. Lakehurst.

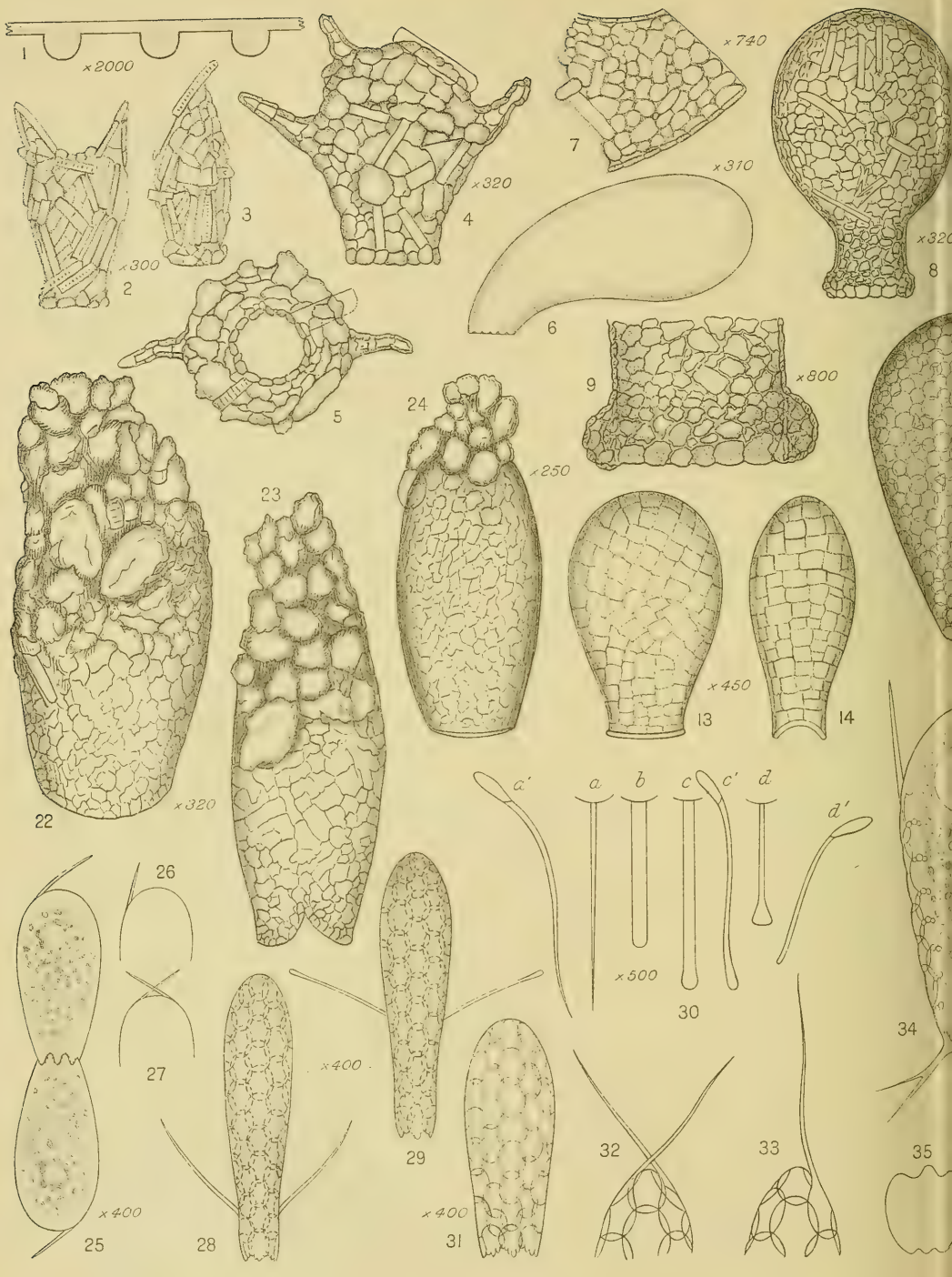
40. PLACOCYSTA SPINOSA var. SETIGERA, var. nov.; × 320.

41, 42. NEBELA GRACILIS var. STOMATA, var. nov. 41, Broad, and 42, narrow, views of test. Seychelles.

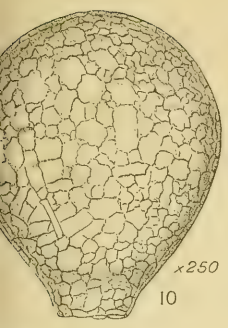
43. NEBELA SCUTELLATA, sp. nov.; × 520. Seychelles.

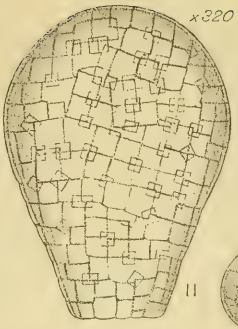
44. NEBELA TROPICA, sp. nov.; × 520. Seychelles.

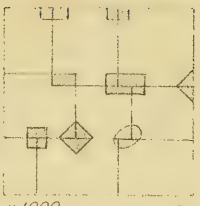
45. QUADRULA SYMMETRICA (Wallich), F. E. Schulze; × 520. Seychelles.

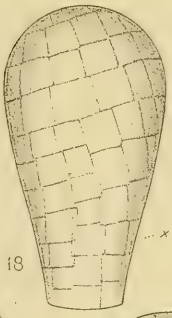


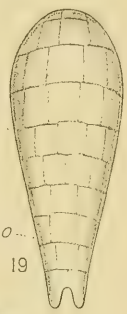
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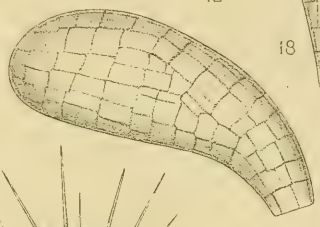


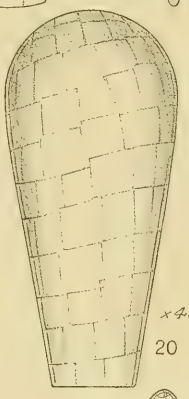




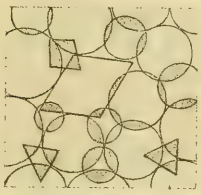


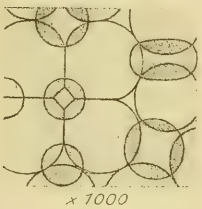


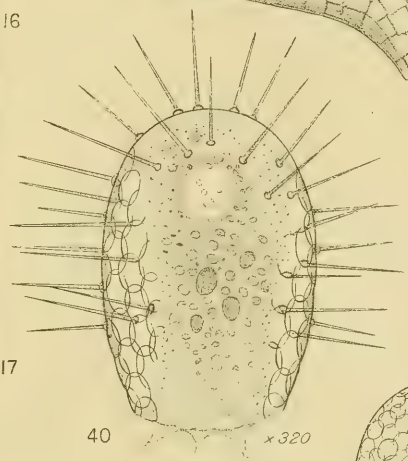


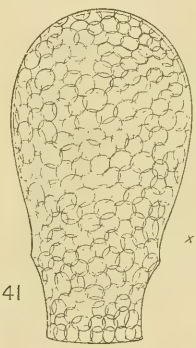


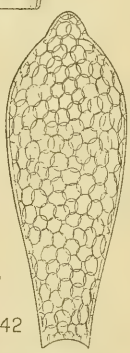




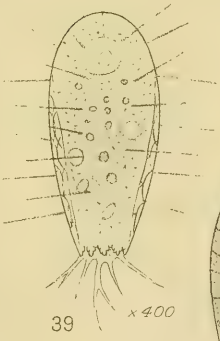


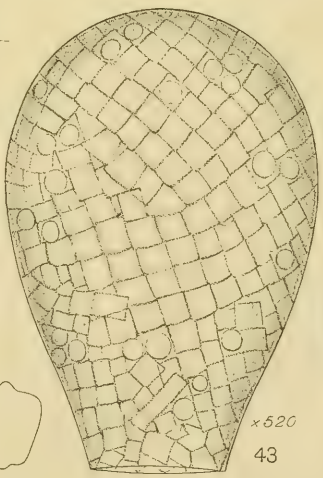


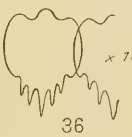


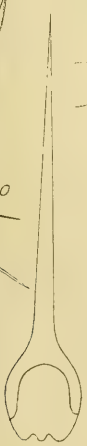


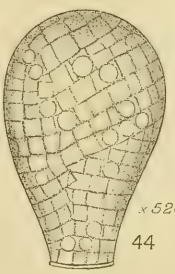


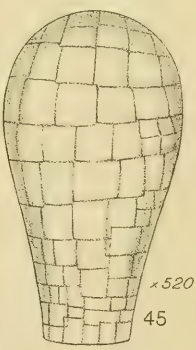












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THE JOURNAL

OF

THE LINNEAN SOCIETY.

Vol. XXXII. ZOOLOGY. No. 215.

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Spolia Runiana.—I. *Funiculina quadrangularis* (Pallas) and the Hebridean *Diazona violacea*, Savigny.

By W. A. Herdman, F.R.S., F.L.S., Professor of Zoology in the University of Liverpool.

(Plates **13** & **14** and 2 Text-figures.)

[Read 5th December, 1912.]

The main part of our scientific work on board the yacht 'Runa' is planktonic and consists of surface and mid-water horizontal and also of vertical hauls from the deep fjords on the west coast of Scotland. The results of these plankton gatherings are reported on in detail elsewhere *.

The fish-trawl and the naturalist's dredge, are, however, also used from the yacht as often as can be managed, and I should like occasionally to make known to the Linnean Society any "Spolia Runiana" of special interest or novelty that may be brought up from the sea-bottom during our cruises.

In the past summer we spent about a month (August 1912) cruising on the west of Scotland, both amongst the inner islands (Mull, Skye, &c.) and also along the chain of the Outer Hebrides from Barra Head to Stornoway, dredging and townetting almost daily. Two of the more interesting animals obtained—the only ones I shall refer to in this communication—were the giant sea-pen *Funiculina quadrangularis* (Pallas) and the Compound Ascidian *Diazona violacea*, Savigny, first described from the Hebrides by Forbes and Goodsir under the name "*Syntethys hebridicus*," in 1851.†

(1) Funiculina quadrangularis (*Pallas*).

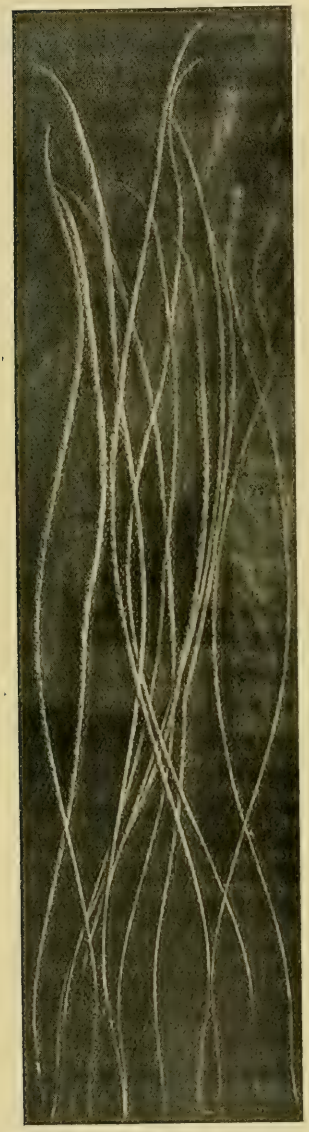
The late Professor A. Milnes Marshall and his father, Mr. W. P. Marshall, in their little book entitled 'Report on the Oban Pennatulida' (Birmingham, 1882), gave a detailed account of this "rare and interesting species," and of the circumstances under which it was dredged, in 1881, by members of the Birmingham Natural History Society at two localities in the Firth of Lorn, between Oban and the island of Lismore. It is rather surprising to read that on that occasion only four living specimens and three of the calcareous skeletons were obtained, and that the largest was only 39 inches in length, since we on the 'Runa' this summer brought up a score or more of larger specimens in every haul of the dredge, at that spot, along with very many smaller ones which were thrown back into the sea. Our largest specimen is

* Lancashire Sea-Fisheries Laboratory Annual Report for 1912.

† See Addendum, p. 171, with lists of Amphipods and Echinoderms.

now, in its preserved state, 62 inches in length, several others are about 5 feet, and we obtained a good many (at least 20) of 4 feet or a little over.

Fig. 1.



Funiculina quadrangularis (Pallas), from a photograph.

The Marshalls describe the upper part of the colony as being "of an ivory-white colour," but note that both Forbes and Wyville Thomson had recorded it as being "rose-coloured." Our specimens when alive were certainly of a pale translucent rosy tint, and a few colonies that I preserved in a 10 per cent. solution of formol in sea-water have still (after four months) the same beautiful colour and life-like appearance, while those put into alcohol have become opaque and vary from a creamy-white to yellowish-brown. Fig. 1 shows a group of these preserved specimens.

The first British specimens were apparently dredged in 1844, at this same locality, by Mr. R. McAndrew from his yacht, and were described by Prof. Edward Forbes in the 'Annals and Magazine of Natural History' (vol. xiv.). Sir Wyville Thomson, in 'The Depths of the Sea,' records having dredged "Pavonariæ" (=*Funiculina*) from 100 fathoms in Raasay Sound, and refers to their "pale lilac phosphorescence." He remarks further that from the number of specimens brought up at one haul "we had evidently passed over a forest of them"; and that is exactly the impression that was produced upon myself and upon my friend Mr. A. O. Walker, F.L.S., who was with me when we brought up such quantities of living colonies in the Firth of Lorn last August. It is probable that in our hauls from the 'Runa' we dredged through the thickest of the plantation, while the Birmingham naturalists in 1881 may possibly only have skirted along its edge. I may add that in our hauls most of the larger specimens were not actually in the trawl-net (which contained quantities of fine mud), but were balanced across the front of the frame (a 6-foot Agassiz trawl), and especially in a large bunch at each end, in such a precarious position that I had to go off in a punt and pick them out by hand before allowing the net to be raised above the

surface—and one wondered how many still finer specimens had dropped off in coming up through the water.

I can agree with the Marshalls' remark: "Not only is the geographical distribution of *Funiculina* a very limited one, but wherever it does occur it seems to be confined to a very small spot, in which it occurs fairly abundantly"—although I do not doubt that other localities will yet be discovered on the west coast of Scotland containing virgin forests of this largest and stateliest of the British Cœlenterata.

(2) Diazona violacea, Savigny.

This well-known Mediterranean Tunicate was described and figured by Savigny in 1816, and the genus *Diazona* was placed by him in the "Téthyes composées," immediately after *Clavelina*: both in description and figure the colour is given as a beautiful violet. Other notable characters in the original description are: the branchial and atrial apertures both 6-rayed, the internal longitudinal bars of the branchial sac provided with papillæ, and the meshes of the branchial sac containing each four stigmata. As we shall see, the latter two characters require some qualification. The first British specimen was found over sixty years ago by Edward Forbes and John Goodsir, in 30 fathoms of water, off the Croulin Islands, near Skye, and was described by them as a new genus and species under the name *Syntethys hebridicus* in the 'Transactions of the Royal Society of Edinburgh' for 1851 (vol. xx. p. 307). In this paper, Forbes and Goodsir tell how they were at the time on a yachting cruise "with our indefatigable friend Mr. McAndrew* among the Hebrides, in the month of August, 1850"; and in describing their discoveries they go on to say—"the most remarkable of them is the largest of Compound Ascidians yet discovered in the Atlantic. Its nearest described ally is the genus *Diazona* of Savigny, between which animal and *Clavelina* it constitutes a link; one of considerable zoological importance"—and more to the same effect, showing that Forbes and Goodsir had compared "*Syntethys*" with *Diazona* and regarded it as generically distinct. They point out that their "remarkable animal" is of an apple-green hue, that the branchial and atrial apertures are not lobed (although the atrial has six white ocelli), that the ascidiozooids have a sessile abdomen and are marked by lines of white pigment, that the branchial sac has 13 rows of stigmata, hooked fleshy tubercles at the angles of the meshes, and only one of the stigmata in each mesh. Forbes and Goodsir give a coloured figure of their colony, from which my fig. 2, on Pl. **13**, is copied, to give some idea of the distinctly green colour of the living animal. It is, however, in this figure,

* Mr. Robert McAndrew was a Liverpool merchant who owned the yacht 'Naiad,' a 70-ton yawl, which he made good scientific use of on dredging expeditions, chiefly in the interests of conchology.

not sufficiently delicate in its shades and is not sufficiently gelatinous and translucent in appearance.

Alder *, in 1863, described a specimen from the Channel Islands which seemed to bridge the gap between *Diazona* and *Syntethys* so effectually that he placed Forbes and Goodsir's species under Savigny's genus as *Diazona hebridica*, and he showed, moreover, that the living apple-green colour of his Guernsey specimen changed to violet on preservation in alcohol. The apertures of his specimen were obscurely 6-lobed, and consequently many subsequent writers have considered all these specimens to be the same species of *Diazona*, and the name "*hebridica*" has dropped out of use. The animal has since been found repeatedly in the Mediterranean (at Naples and elsewhere), off the coasts of Brittany, and near Plymouth. Garstang †, in 1891, pointed out some differences in detail between specimens from Plymouth and the description given by Forbes and Goodsir, and suggested the possible specific distinctness of the Hebridean form (*D. hebridica*) from all the rest (*D. violacea*). He concludes with the remark: "the whole matter is so beset with doubts that it is greatly to be desired that specimens should be obtained again from the Hebrides, and their anatomy re-described." Following upon this I published ‡ a brief note upon a Hebridean *Diazona* dredged off the north coast of Mull by the late Duke of Argyll, and sent to me for identification through Sir John Murray. I showed in this paper that all the supposed points of difference between the Mediterranean *Diazona* and the Hebridean *Syntethys* can be bridged over by examining in detail a sufficient number of ascidiozooids. Neither in the lobing of the apertures nor in the minute anatomy of the branchial sac can any constant character be found which will enable us to divide the specimens I have examined into two sets, "*hebridica*" and "*violacea*." The question of colour I shall return to below.

In recent systematic works on the Tunicata, such as Bronn's 'Thier-reich' (1909), and 'The British Tunicata,' by Alder and Hancock (Ray Society, 1912), *Syntethys hebridicus* has been accepted as a synonym of *Diazona violacea*, but probably without any further examination of Hebridean specimens.

Now we turn to the new material. While dredging from the 'Runa' this summer, specimens of *Diazona* closely resembling Forbes and Goodsir's *Syntethys* were found, as follows:—

(1) August 7th, a few miles south of Barra Head, in the Atlantic, 60 fathoms, one large colony measuring $9\frac{1}{2} \times 7\frac{1}{2} \times 5$ inches, and of a beautiful translucent pale green colour.

* Ann. & Mag. Nat. Hist. (3) xi. p. 169.
† Journ. Mar. Biol. Assoc. for May 1891, p. 47.
‡ Ann. & Mag. Nat. Hist. for Aug. 1891, p. 165.

(2) August 12th, on East Shiant Bank, in the Minch, north-east of Skye, 27 fathoms ; some smaller pieces, also pale green.

Fig. 1 on Pl. **13** is reproduced (half-size) from a water-colour sketch of the largest 'Runa' colony when alive, made by my wife on the yacht, and I give, for comparison, in fig. 2 a copy of the original illustration in Forbes and Goodsir's paper—both figures showing the green colour of life.

One of the smaller pieces obtained this summer was preserved in formalin, and it is still of the same pale transparent green hue as when alive. Another fragment was preserved in alcohol, and it has become of a pale purple or mauve tint, such as is shown in the little rectangle labelled A on Pl. **13**. The largest colony was placed in a tank of methylated spirit and shut up until the end of the cruise. On opening the tank a month later it was found that the spirit was stained a rich green and the Tunicate colony was now of a well-marked violet colour (like the little rectangle B on Pl. **13**), recalling vividly the appearance of *Diazona violacea* from the Mediterranean.

There can be no doubt then (as I find Mr. J. Hopkinson adds in a footnote to the Supplement of Alder and Hancock's 'British Tunicata,' vol. iii. p. 100, Ray Society, 1912) that *Syntethys hebridicus*, Forb. & Goods., is merely a synonym of *Diazona violacea*, Sav. The only doubt that remained was as to whether the green Hebridean form could be separated as another species of the same genus, but an examination of the detailed structure of the ascidiozooid in colonies from both the Mediterranean and the Hebrides has satisfied me that there are no grounds for such a separation. I have now before me the following material in alcohol :—

Colony from Naples, 1890, colour mauve;
Colony from Naples, 1912, colour dull greyish green ;
Colony from Plymouth (large ascidiozooids), colour mauve;
Ditto (basal part, with small ascidiozooids), colour greyish green ;
Colony from Mull, 1885, colour mauve ;
Colony from Hebrides ('Runa'), 1912, colour violet ;

and although these specimens differ considerably in colour and appearance, they all agree in structure. The branchial and atrial apertures are, I believe, always 6-lobed, although in contracted or badly preserved specimens it may be difficult to demonstrate the lobes. I give (Pl. **14**. figs. 1 & 2) drawings of 6-lobed apertures in both test and mantle from my Hebridean specimen. Then in regard to the structure of the branchial sac every specimen shows a wide range of variation in the number of stigmata in a mesh and in the exact condition of the internal longitudinal bars, as I shall show in detail below.

It is stated in the second volume of 'The British Tunicata' by Alder and Hancock, edited by Hopkinson (Ray Society, 1906), that *Diazona* has "the intersections of the meshes papillated" (p. 159) ; and in *D. hebridica* stout papillæ are both figured and described (p. 162) and are stated to be a

character that may enable the Hebridean to be separated from Savigny's species with "slender, pointed" papillæ. But, as a matter of fact, neither the southern nor the northern form has any papillæ at all in the branchial sac, as was explained * in my paper in 1891. As I stated then, the "hooked fleshy tubercles" (=papillæ) of Forbes and Goodsir's description can be quite satisfactorily accounted for by the corrugation of the internal longitudinal bars, the thick prominent connecting ducts which seem to project on each side where they join the bars, and the imperfect condition of the bars in some parts of the sac. When a branchial sac is first opened, in the case of most ascidiozooids, and is examined in water under a low power of the microscope, the appearance of large papillæ at the angles of the meshes is so distinct that it is difficult to realise, until the specimen has been stained, mounted, and examined in detail with a high power, that only connecting ducts and more or less irregular bars are present. There is no difficulty in understanding how it is that some previous investigators have fallen into the error of supposing that they saw large papillæ. Figs. 4 to 16 on Pl. **14** illustrate these remarks. Figs. 5, 6, & 16 show corrugated internal bars forming projections, but without any true papillæ ; figs. 4, 12, 13, & 14 show connecting ducts which have not grown together to form bars, and so give a deceptive appearance of being large papillæ.

In regard to the supposed difference between the two forms in the number of stigmata in a mesh, the range of variation is great (see figs. 10 to 15) and is much the same in all the specimens I have examined, as is shown by the following note :—

Naples (1912)	specimen has	2–3	stigmata in a mesh.
Mull (1885)	,,	1–4	,,
'Runa' (1912)	,,	1–3	,,
Plymouth	,,	1–3	,,

Probably some parts of each of the branchial sacs could be found showing the four stigmata in a mesh described by Savigny, and certainly many parts show the single stigmata referred to by Forbes and Goodsir. The stigmata are found to differ also very greatly in size and shape in different parts of the same sac (fig. 9).

The distinctions depending upon lines of white pigmentation on the ascidiozooids referred to by Forbes and Goodsir, Giard, Lahille, and others are so slight and so unreliable that in the absence of any real structural differences they need not be considered. Lahille regards them as at most serving to separate the type and two varieties which he proposes to call :—

(Type) *D. violacea*, Sav.—(Mediterranean.)
(Variety 1) *D. hebridica-violacea*, Forb.—(Hebridean seas.)
(Variety 2) *D. intacta-violacea*, Lah.—(Banyuls.)

* And was also shown by Lahille in the case of the Mediterranean form (Recher. sur les Tuniciers, Toulouse, 1890).

According to this nomenclature our 'Runa' specimens would fall into the first variety, the name of which I would prefer to write as *Diazona violacea*, Savigny, variety *hebridica*, Forb. & Goods.

Turning now to the colour of the colony as a whole, and to the change of colour that has been described, we find that the curious point about the colour of this animal is that, whereas British specimens are green when alive and become violet when preserved in spirit, Mediterranean specimens are apparently sometimes violet and sometimes green, and the latter do not always change their colour when treated with alcohol. Professor R. Dohrn, Director of the Zoological Station at Naples, has kindly sent me a pale green *Diazona violacea* preserved in alcohol, and he informs me that both green and violet-coloured specimens have been obtained from time to time in the neighbourhood of Naples. He states that it has not been noticed in their preservation department at the Zoological Station that any change of colour takes place on adding alcohol ; but he adds in his letter that he remembers to have noticed that the green *Diazona* becomes of a bluish colour when injured *.

It is remarkable that my large violet-coloured 'Runa' colony still continues after four months' preservation to give out the green pigment, as three successive changes of spirit have now been coloured by it. The violet pigment of the preserved specimen, however, seems to be insoluble, as fragments so coloured have been kept in absolute alcohol, in chloroform, in bisulphide of carbon, and in xylol for weeks without showing any change in tint.

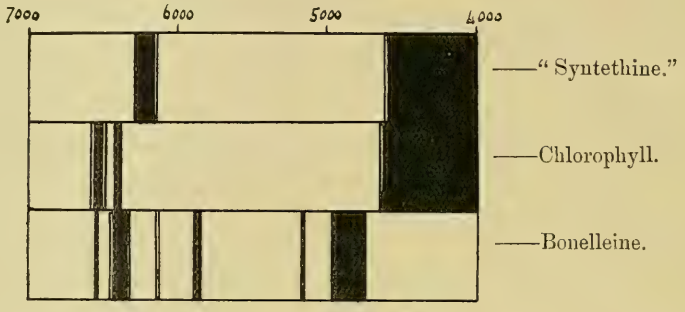
The brilliant green solution which this Hebridean specimen has given with alcohol has been examined spectroscopically for me by Dr. Alfred Holt, Reader in Physical Chemistry in the University of Liverpool, and he has shown me that the pigment is not chlorophyll—as might have been supposed at first—but has a characteristic absorption band in the orange intermediate in position between the band given by sodium and that of chlorophyll. The position of this band in Ångstrom units is 6200; while chlorophyll gives a band at 6550, and bonelleine, described by Sorby in 1875 from the green Gephyrean worm *Bonellia viridis*, has a corresponding band in the orange at 6430. In chlorophyll there is much greater absorption at the blue end of the spectrum, and in "syntethine," as observed, there is almost an identical effect, while in bonelleine there is a well-marked band in the blue and relatively less absorption in the indigo and violet.

The "Syntethys" pigment (we do not know yet whether it can be obtained also from the *Diazona* that is violet when living) does not go purple with acids, and therefore cannot be bonelleine. Acids or alkalies turn it some-

* F. Lahille states (1890) that specimens at Banyuls kept in aquaria degenerate, and that their pale yellowish colour becomes bluish or violet.

what yellowish, and the colour is not restored on neutralisation. No distinct bands are shown in acids or alkaline solutions. Possibly our substance and bonelleine belong to the same natural group (what Sorby called a "genus") of pigments. Dr. Holt has kindly supplied me with a diagram (fig. 2)

Fig. 2.



showing the spectrum of the new pigment—to which the name "syntethine" may be appropriately applied—compared with those of bonelleine and of chlorophyll.

The violet of the large 'Runa' colony in its present condition is the complementary colour to the green which has been dissolved out of it, so that when the colony is submerged in the solution it appears to lose at once its brilliant colour and become dull grey. The question then arises—was the violet pigment present, masked by the green, when the animal was living; or has chemical action taken place, possibly due to dehydration by the alcohol, which, while dissolving out the green, caused the precipitation of another previously less conspicuous pigment in the present opaque violet form; or, are the green and the violet two forms of the same pigment partly dissolved out in the green form and partly precipitated as the insoluble violet?

Histologically the violet colour is due to minute opaque granules closely placed in the spherical pigment cells with which the test is found to be crowded (see Pl. **14**. fig. 3). Similar opaque green pigment cells are visible in abundance in the test of the 'Runa' specimens which are preserved in formalin (Pl. **14**. fig. 1).

It is evident that the little we know of this pigment does not yet throw any light upon the curious colour changes in *Diazona*, and fails as completely as the structural characters to afford any evidence of specific distinction between the Mediterranean and the Hebridean forms. "Nimium ne crede colori" may be a sound aphorism for the systematist in some groups, but still colour does mean something and may mean a great deal from the physiological point of view.

The colony of *Diazona* is known to undergo remarkable degenerative and



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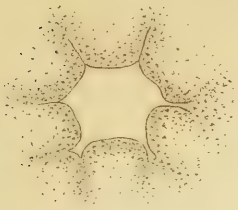
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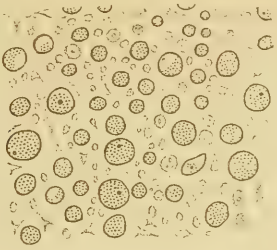
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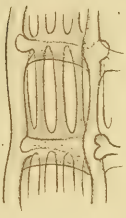
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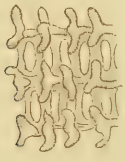
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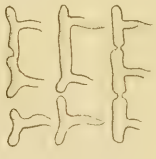
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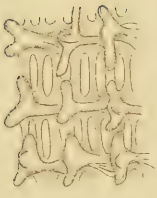
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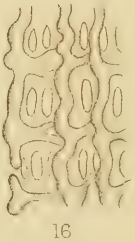
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14



15



16

W. A. Herdman del.

West, Newman lith. & imp.

DIAZONA.

regenerative changes in its life-history, involving, no doubt, profound alterations of the metabolism; and it occurs to me as possible that, if green is the normal colour when in full vitality, those Mediterranean specimens which are described as violet when alive may be in the state preparatory to regeneration when the abnormal life-processes may have caused a chemical change in the pigment similar to that produced in the green Hebridean forms when treated with alcohol.

EXPLANATION OF THE PLATES.

Plate 13.

Fig. 1. Colony of *Diazona violacea*, dredged in the Outer Hebrides, Aug. 1912; about one-half natural size. From a water-colour sketch of the living animal.

2. From Forbes and Goodsir's coloured figure of "*Syntethys hebridicus*," published in 1851; slightly reduced.

A. To show the mauve colour of some preserved specimens.

B. To show the violet colour of the large 'Runa' specimen (fig. 1) after preservation in alcohol.

Plate 14.

Fig. 1. Branchial aperture in the test of a Hebridean (green) *Diazona*, to show the 6 lobes; slightly enlarged.

2. Branchial aperture in the mantle of the same Hebridean *Diazona*, to show the 6 lobes; slightly enlarged.

3. Part of the test of a violet *Diazona*, to show the conspicuous pigment cells and the colourless test cells; high power.

Figs. 4 to 8. From a Naples specimen, to show the variations in the character of the branchial sac. Fig. 8 shows the epithelium on a bar opposite the junction with a connecting duct.

9 & 10. From a Mull specimen (Duke of Argyll, 1885), showing variations in numbers and sizes of stigmata.

11 to 13. From a Plymouth specimen, showing variations in the conditions of the bars.

14 to 16. From a Hebridean ('Runa,' 1912) specimen, showing variations in the characters of the branchial sac.

With the exception of fig. 8, which is a high-power view, figs. 4 to 16 are all of the same magnification, about 40 diameters.

Addendum.

On the Amphipoda, &c., collected from the 'Runa,' by Alfred O. Walker, F.L.S.; and List of the Echinodermata collected from the 'Runa,' by H. C. Chadwick, A.L.S.

At the meeting of the Society, on December 5th, when the preceding paper was read, Mr. A. O. Walker made some remarks in regard to the Crustacea collected, and read a list of the Amphipoda and Isopoda which he

had identified and which he afterwards sent to me for incorporation in this paper. It is as follows :—

**Aristias neglectus*, Hansen.
Perrierella Audouiniana (Sp. Bate).
Tryphosa Sarsii (Bonnier).
Ampelisca tenuicornis, Lillj.
„ *spinipes*, Boeck (young).
Haploöps tubicola, Lillj.
Amphilochus manudens, Sp. Bate.
Leucothoë spinicarpa (Abildg.).
Cressa dubia, Sp. Bate.
Stenothoë marina (Sp. Bate).
Colomastix pusilla, Grube.
**Panoplœa Eblanæ* (Sp. Bate).
Neopleustes bicuspis (Kröyer).
**Sympleustes latipes* (M. Sars).
Epimeria cornigera (Fabr.).
Melita obtusata (Montagu).
Maera Othonis (M.-Edwards).
**Photis Reinhardi*, Kr.
Eurystheus maculatus (Johnston).
Leptocheirus pectinatus (Norman).
[? = *L. pilosus*, Zadd.] †
Jassa pusilla (G. O. Sars).
Erichthonius brasiliensis (Dana).
Proto pedata (Müller).
Astacilla longicornis (Sowerby).
Janira maculosa, Leach.

The four species marked with a star have not been found by us in the Irish Sea area.

This is probably the most northerly record of *Colomastix pusilla*, Grube. It was found on the Ceylon Pearl Banks in 1902 (see Herdman's Report, Royal Society, Part II. p. 299).

Panoplœa Eblanæ (Sp. Bate) is a Mediterranean species. The most northerly record hitherto is that of the type described by Spence Bate from specimens taken from the branchial cavities of *Rhizostoma* from Dublin Bay. It appears to be very rare in British seas, as it does not even occur in the magnificent collection presented to the British Museum by Canon A. M. Norman, as I am informed by Dr. Calman, who identified this species.

Mr. H. C. Chadwick, A.L.S., has identified the Echinodermata of the cruise as follows :—

Holothuria tremula, Gunner.
Phyllophorus Drummondi (Thomps.).
Antedon Milleri (Wyv. Thom.).
„ *phalangium* (J. Müll.).
„ *bifida* (Penn.).
Luidia ciliaris (Phil.).
„ *Sarsi*, Düb. & Kor.
Palmipes placenta (Penn.).
Solaster papposus, Fabr.
„ *endeca*, Linn.
Asterias Murrayi, Bell.
Asterias Muelleri (Sars).
„ *rubens*, Linn.
Porania pulvillus (O. F. Müll.).
Ophiura ciliaris (Linn.).
„ *albida*, Forb.
Amphiura Chiajii, Forb.
Ophiopholis aculeata (Linn.).
Asteronyx Loveni, M. & T.
Spatangus purpureus, O. F. Müll.
Brissopsis lyrifera, Forb.
Echinus esculentus (Linn.).

The Hebridean specimens of *Echinus esculentus*, compared with those commonly found at the Isle of Man, are uniformly higher and more pentagonal in shape, and have the primary tubercles on both ambulacral and interambulacral plates smaller in size and number, and the secondary tubercles much more feebly developed. The arrangement of the pores on the ambulacral plates is also slightly different in the two cases.

† These two are considered distinct by Mrs. Sexton (Proc. Zool. Soc. Lond. 1911, p. 561)

Revision of the Linnean Types of Palæarctic Rhopalocera.

By Roger Verity, M.D., F.It.E.S., F.Fr.E.S. (Communicated by the President.)

[Read 6th February, 1913.]

The kindness of Dr. B. Daydon Jackson has enabled me to examine the insects of the Linnean collection, which, as is well known, was purchased and brought to England in 1784 by Dr. J. E. Smith, and subsequently became the property of the Linnean Society.

Unfortunately the types of all the insects described by Linnæus were not in his collection, as he also largely used that of the Baron Charles De Geer, now preserved in the Royal Academy of Science in Stockholm, and that of the Queen Ludovica Ulrica, which is now in the Uppsala University.

Most of the Palæarctic Rhopalocera belonged, however, to Linnæus, as will be seen in the following pages; and the opportunity I have had of examining them has enabled me to make observations which cast light on several points of interest. Some of these have been the object of long controversies amongst entomologists, owing to insufficient original descriptions, and others reveal mistakes which have been carried on for a century and a half, and which were so thoroughly rooted by habit that nobody ever suspected their existence. I hope in consequence that this note may prove to be of some interest, and that it will encourage others to do a similar work on the other Rhopalocera and on the Heterocera, which, I have no doubt, would yield as interesting results.

Dr. Daydon Jackson's thorough knowledge of the works and life of Linnæus has been of invaluable assistance to me. Thus it is important to know that he received many insects from Erik Brander, who was Swedish Consul at Algiers from 1753 to 1765: consequently the types of some of the common European species actually are African, and the "nimotypical" race is that which flies in Africa, as will be observed. Linnæus also had several correspondents in Germany and one in Hungary, as may be inferred by the localities of his insects. I have found no evidence that Kähler, who collected plants for him in several Italian localities, ever furnished him with insects.

One of the difficulties met with in working out the Linnean specimens is due to the great amount of examples that Smith added to the collection. However, after I had acquired some practice, I found that I could separate the insects nearly always with absolute certainty, availing myself of several data:—(1) the labels in Linnæus's own handwriting; (2) the pins which

he used and which were longer, thicker, and coarser than Smith's ; (3) the way the wings were set ; (4) the important fact that Linnæus marked in his own interleaved copy of Syst. Naturæ, XII. edit., every species he possessed specimens of, by underlining with ink the number corresponding to it. With but one or two exceptions, I have been able to find all the specimens thus recorded; and in some instances I found a specimen labelled by him in the collection, but which he had evidently forgotten to mark in the book. Smith followed the same method, but fortunately always used pencil-marks.

It must furthermore be borne in mind that, as regards the species described in the work on the Queen Ludovica Ulrica's Museum (few in the case of Palæarctic), Linnæus's specimens cannot be regarded as the actual "types," but only as "co-types." We know that the Queen presented Linnæus with duplicates when she possessed more than two examples, and we also learn from Brander's letter, dated 23rd of August, 1756, that he used to send series of specimens both to the Queen and to Linnæus.

Entomologists do not seem to have in all cases noted in which of Linnæus's works the first description of the different species appeared ; so I have thought it useful to mark the date of the original description after each one, and it should be understood that they refer to the following works :—

1758. Systema Naturæ, X. edit.
1761. Fauna Suecica, II. edit.
1764. Museum Ludovicæ Ulricæ.
1767. Systema Naturæ, XII. edit.

In the following list of Linnean species I have adopted the modern generic nomenclature and classification, so as to render reference easier ; at the head of each paragraph I have noted the specimens which I have been able to recognise with certainty as Linnean, and added a few observations which I think may be of some interest.

In all cases in which the examination of the types seems to necessitate alteration in nomenclature, I have endeavoured to set forth as clearly as possible the grounds on which I venture to suggest these alterations, with a view to coming to a definite settlement. At the end of this paper a list of these alterations is given.

The species marked by Linnæus as being in his collection are in the following pages marked by an asterisk, thus, *.

*Papilio podalirius [(1758)–1764]. Only one Linnean specimen, which bears this name in Linnæus's handwriting. It is a female of the butterfly generally known as *P. feisthameli,* Dup., African summer brood *lotteri,* Aust. —The other specimen which accompanies it bears a date (1786) posterior to the transference of the collection to England.

If one goes over the earlier literature concerning the name *podalirius*, we find that it figures amongst the very first created by Linnæus, but unfortunately in a very unsatisfactory way : it is only mentioned in a short footnote on p. 463 of the X. edit. of 'Systema Naturæ' ; no description accompanies it, but only the following quotations : Ray, Historia Insectorum, p. 111. n. 3 (1710) ; Réaumur, Hist. des Insectes, i. pl. 12. figs. 3, 4 (1734); Rösel, Collect. of Insects, i. classe ii. pl. 2 (1746). Linnæus then gives Southern Europe as habitat, and adds that this butterfly is so similar to his American *protesilaus* that a thorough acquaintance with their early stages will alone prove whether they are to be considered specifically distinct.

Evidently Linnæus was not personally acquainted with this insect in 1758. When Brander's African specimens reached Sweden the author of 'Systema Naturæ' cancelled with a few pen-strokes on his own copy of the book the footnote referring to *podalirius*, and in 1764 published a lengthy description of the African species he had in hand, under the same name of *podalirius*.

If it be borne in mind that the three authors quoted by him figure or describe the species which is more widely distributed in Europe, as is ascertainable by referring to their works, it comes to be clear that Linnæus applied a single name to two insects which the most recent observations have proved to be specifically distinct *.

We are thus confronted with the question, for which of the two ought the name to be used? and it seems to me that the most satisfactory plan is to consider, as its own author did, the first mention of the name in 1758 as null: the lack of any description, and the imperfect and incorrect statements accompanying it proving that Linnæus did not know the insect he was mentioning, would, according to my views, be quite sufficient ; furthermore, the original description of 1764 is given full value by the documentary evidence of one of the very specimens from which it was drawn.

If this were not enough, one might also add that before Linnæus's description was published the European species had already been carefully described and figured by the first author who took up the new nomenclature, Nicolaus Poda. In his 'Insecta Musæi Græcensis' (1761) he gave such a good figure of a female of the summer brood that it can be readily identified, and, never suspecting it was the insect mentioned by his master in the aforesaid footnote, he gave it the name of *P. sinon*.

This name I propose to validate as specific. If it be accepted, several alterations will be found necessary amongst the names of the different races and broods. The summer brood becoming nimotypical, the spring brood will have to receive a name instead : *flammæus* of Fourcroy, Entom. Paris,

* See R. Verity, 'Rhopalocera Palæarctica,' p. 293. I emphasize the fact that *P. sinon* and *podalirius* (= *feisthameli*, Dup.) both fly together in Spain and Portugal and even down to Tangier in Marocco.

ii. p. 242 (1785), cannot be adopted, because its description gives no clue as to what generation the type belonged. In consequence, a name must be created, and I propose that of *vernus*.

As regards the Hispano-African species, it will be found useful to maintain the name *feisthameli*, Duponchel, whose original figure represents the Spanish summer brood, to distinguish it from the nimotypical African race, quite distinct from it in all the broods (see Synopsis of Alterations at the end of this note).

*Papilio machaon [1758]. The specimen, which is certainly Linnean and which bears his label, is a female of the first (or only) brood of a northern race, as may be inferred by its light yellow ground-colour, short tails, and narrow transverse bands, with their inner contour undulating but not produced in sharp dents. Another specimen, of doubtful origin, is certainly southern, and a third is a British specimen from the Smith collection.

Thais rumina [1758]. No Linnean specimen.

*Parnassius apollo [1758]. No specimen bears a Linnean label, but everything points to the fact that one of the three specimens in the collection was Linnæan. It is a female of large size of the Scandinavian race. Two more specimens, from Italy, are Smith's.

*Parnassius mnemosyne [1758]. A male and a female, the first of which is labelled by Linnæus. These two specimens evidently come from the same locality; they are of a large, very white race, with the black markings much reduced and no white patches in the vitreous marginal band. They probably come from Finland, which locality Linnæus gives as only habitat in his original description; but, as he adds Hungary in the XII. edit. of the Syst. Nat., I could not certify these specimens are not Hungarian, owing to the resemblance of certain individuals of the two races. At all events, it seems plausible to consider the northern race as nimotypical †.

*Aporia cratægi [1758]. One male specimen labelled by Linnæus is distinctly of Scandinavian origin; the other English specimen is not Linnean.

*Pieris daplidice [1758]. The specimen, which is obviously Linnean and bears his own label, is a female of the summer brood; another female and a male are probably from Linnæus's collection as well. They all three belong to the large European race, with the black markings widespread and their outlines diffused and with broad and vividly green markings on the underside, contrasting with the form or race, as the case may be, *nitida*, Verity.

† See 'Rhopalocera Palæarctica,' p. 320.

*Pieris napi [1758]. Only one specimen ; this is obviously Linnean, and bears his label. It is a male of the Scandinavian race : small, basal suffusion of wings widespread and very black ; apical marking extending far backwards along outer margin; on the underside neuration of fore wings distinctly bordered with grey scaling, that of hind wings with very broad and very dark olive-green veins. The female is English and has been added in by Smith.

The Linnean "type" is identical with the specimen I have figured in 'Rhopalocera Palæarctica,' pl. 32. fig. 32, *i. e.* to the race which on p. 333 I discussed and proposed to distinguish under the name of *arctica*, assuming the nimotypical form to be the common spring form of Central and Southern Europe. In reality the Scandinavian race is more closely allied to the Alpine *bryoniæ* than to the so-called *napi*, but as it seems to constitute a sort of intermediate race between the two, I should not be inclined personally to substitute the name of *napi* for that of *bryoniæ* simply on this ground ; moreover, the present state of things regarding this group of *Pieris* is very unsatisfactory, and as yet we have reached no definite conclusion as to the biological degree of distinctness between *napi*, *bryoniæ*, *ochsenheimeri*, *frigida*, and the allied North-American butterflies.

Suffice it, then, now to have established that the Scandinavian race is the nimotypical one, and to distinguish from it the well-known butterfly of Central and Southern Europe whose summer brood Esper has named *napææ*, and which in the first generation, though more similar to *bryoniæ* and the Linnean *napi*, can be distinguished from it by its larger size, more elongated wings, very reduced basal suffusion, shorter apical black crescent, shadeless neuration of the underside of fore wings, narrower, more sharply outlined and more vividly green veins of hind wings, and by the fact that the female never offers examples of the form with yellow ground-colour and ample brown suffusion.

I propose the name of *vulgaris*, taking as typical the first brood of the neighbourhood of Florence (Italy), because amongst the races I know it is that which keeps most constantly distinct from the Linnean one.

If it be biologically proved in future that this butterfly is specifically distinct from *bryoniæ*, no doubt the Linnean race will have to be grouped with this last and *vulgaris* will rise to specific rank as compared with *napi*, whilst the name *bryoniæ* will serve to differentiate the Alpine race from the Arctic one.

*Pieris rapæ [1758]. The only Linnean specimen bears his label. It is a male of the first brood, with pale grey apical crescent, no discoidal spot, and underside of hind wings suffused with a thick black dusting ; presumably Scandinavian.

Thus we find that the Linnean nimotypical form of this species is identical with *metra*, Stephens (1827), and *immaculata*, Fologne (1857), and that it is

the summer brood, whose characters are too well known for me to describe them here, which ought to be distinguished by a name ; according to my views on the subject †, I propose that of *æstivus*.

*Pieris brassicæ [1758]. The only Linnæan specimen bears his label. It is a ♂ of the first brood, with pale grey apical crescent and underside of hind wings suffused with a thick black dusting.

What has been said of *rapæ* can be repeated here, and the name *chariclea*, under which Stephens described the first brood as a distinct species in 1827, falls into synonymy ; however, in this case we have already for the summer brood the name of *lepidii*, proposed by Röber in 1907.

*Euchloë cardamines [1758]. There exist four Linnæan specimens, two of each sex ; they are alike : large apical crescent both on upper and under sides, very widespread and very dark green pattern on the latter side of hind wings, with no traces of yellow. The characters of a northern race are thus developed to a high degree and fully justify the names given to other races.

*Euchloë belia [1767]. Under this name there exist two specimens, one of them bearing Linnæus's label ; they are both females of the species which is generally known as *eupheno*, Linn.

Euchloë eupheno [1767]. No specimen, and in fact not marked by Linnæus as being in his possession.

In the XII. edit. of Syst. Nat. Linnæus describes under the names of *belia* and of *eupheno* the female and the male respectively of a single species. Cramer overlooked this fact, and having evidently also overlooked the character of "rufous apex" given in the description of *belia*, he figured in 1782, under this name, a species which Linnæus had never known. Butler, in 1869, pointed out this mistake and proposed the name of *crameri* for Cramer's insect. As, however, up to the present date nobody knew what butterfly Linnæus's *belia* was, entomologists have preferred to consider it as null, and Butler's name has had no success. Now that it is known, it seems obvious that, as it is desirable to come to some definite settlement based on positive facts, the most reasonable view to take is that of re-establishing the name *belia* for the species it was created for and re-enforcing Butler's name for Cramer's insect. Let it also be noticed that in Syst. Nat. the name *belia* stands before *eupheno*, so that, strictly speaking, according to the International Rules of Nomenclature, it also has the right of priority over the latter, and furthermore that the types of *eupheno* are for the present unknown, so that it is only the habitat "Barberia" which gives a clue as to what species Linnæus meant it for, his brief description fitting *euphenoides* as well. Staudinger did not accept Butler's and Kirby's suggestion of re-establishing

† See 'Rhopalocera Palæarctica,' p. liv.

the name *belia* in the place of *eupheno*, on the ground that Linnæus's description of the former might have been meant for another Algerian species, *T. omphale*. This view cannot stand if one remembers that in the times of Brander no European had ever got to the southern desert regions haunted by *omphale*.

*Leptidea sinapis [1758]. The specimen labelled by Linnæus is a male of the spring brood with very large diffused apical patch of grey at apex and very abundant and dark scaling on underside of hind wings; another specimen is a male of the summer brood, very near the form known as *diniensis*, Boisd., and bears the locality "Hung." in Linnæus's handwriting (it is the only Linnean specimen I have seen with a locality attached to it!).

The original description of this species applies as well to the summer as to the spring brood. The specimen which has been labelled by Linnæus is to all appearance Scandinavian, and, strictly speaking, it probably ought to be taken as the type, because Linnæus presumably only received his Hungarian insects after the X. edit. of Syst. Nat. was published; this may be inferred by the fact that he gives the habitat Hungary for *P. mnemosyne* only in the XII. edit.

This consideration does not seem, however, to be of sufficient value to oblige us to drop the well-known name of *lathyri*, Hübn., for the first brood.

*Colias palæno [1761]. The specimen bearing the Linnean label is in no way the insect which is known under this name; it certainly belongs to the same group, having the underside of hind wings thickly suffused with dark scaling, and a silvery discoidal spot devoid of any ring, but its bright yellow upperside and narrow marginal band with a slightly undulating inner margin and yellow veins partially intersecting it distinguish it promptly; the only butterfly I could refer it to is the American *alexandra*, Edw., whose habitat, however, makes it highly improbable that Linnæus should have obtained it. Two more specimens, which are unmistakably Linnean, are a male and a female of the Scandinavian race of *palæno*.

As the original description is in 'Fauna Suecica,' I should think there was no doubt that Linnæus meant it for the butterfly of his country which he was well acquainted with, and there is no reason to alter the present nomenclature.

*Colias hyale [1758]. Two males and a female, which all have the look of Linnean specimens and seem to be of the summer brood.

*Gonepteryx rhamni [1758]. The Linnean specimen is a male of the northern race: small, light yellow, discoidal spots so small and pale as to be nearly invisible.

Thus Röber is fully justified in having named the race from Africa and Asia Minor, which is transitional to *farinosa*, and I think it equally useful to distinguish the race from Southern Europe, which is intermediate between the race of Linnæus and that of Röber : I therefore suggest giving it the name *transiens*, taking as typical the Italian specimens in my collection.

*Gonepteryx cleopatra [1767]. A ♂, which is obviously Linnæan, and bears his label, unmistakably belongs to the North African race, as may be seen by its rich colouring, by the orange patch of fore wings nearly reaching the external margin, by the underside of a vivid green with a slightly milky appearance.

All these characters correspond to those of the race which Röber named *mauritanica* ; furthermore, Linnæus only gives Barbaria as habitat of this species. There is, in consequence, no doubt that the nimotypical race should be the African one, and as the European one is quite distinct from it, I propose to designate it by the name of *europæus*, taking as typical that which flies during the spring in the neighbourhood of Florence (Italy) ; the form which is produced by extreme heat has already received the name of *italica*, Gerh., but it is by no means the commonest form even in the height of summer.

*Charaxes jason [1758] = *jasius* [1767]. The Linnean specimens are a male and a female of the North African race, as proved by their large size, dark colouring, long tails, and chiefly by the very small size of the greyish-blue spots which, on the hind wing, precede the yellow marginal band.

As in the case of *G. cleopatra*, the only locality given by Linnæus in the XII. edit. of Syst. Nat. is Barbaria (in the X. edit. and in Mus. Lud. Ulr. the locality "India" is obviously erroneous !). The nimotypical race is thus proved to be the African one, and, as that which flies north of the Mediterranean can be constantly separated from it by its inferior average size, by its lighter colouring, shorter tails, and much wider and more prominent blue spots on hind wing, often blending in a continuous band, I think it should be designated by a name. The specimens which are to the greatest degree removed from the African ones are, to my knowledge, the Tuscan, and I propose to take them as typical of a race *septentrionalis*.

*Apatura iris [1758]. There exist four specimens which are obviously Linnean, and two English specimens added by Smith. Of the first, one is a male of the insect generally known as *ilia*, and bears a label of Linnæus, "*iris*" ; another is a male of its form *clytie*, and equally bears the name "*iris*" in Linnæus's handwriting ; a third is a female of this last ; and a fourth is a male of the species generally called *iris* : it is set so as to show the underside.

If we now turn to the Linnean literature on the subject, we find that Linnæus's original description, which he afterwards simply transcribed, is

quite insufficient for us to make out what species it is to be referred to. Fortunately, however, Linnæus has furnished us a clue which proves that the specimen labelled *iris* by him is actually the one he intended to describe. In his own interleaved copy of the X. edit. of 'Syst. Naturæ' he has added a side-note which evidently can only be ascribed to the character distinguishing *ilia* auctorum from *iris* auctorum on the upper side of the wings. I quote the description of the fore wings and add the hand-written note inclosed by brackets: "Primores supra maculis albis sparsis in medio & exterius [et ocello nigro inde ferrugineo]."

It seems to me that those who wish to establish nomenclature once for all on grounds which are not open to criticism will find it advisable to correct the mistake made nearly a century and a half ago, and to re-establish the name *iris* for the species of which Linnæus has left us two types. In consequence, I venture to suggest that the name *pseudoiris* should be adopted for the false *iris* of authors.

Limenitis populi [1758]. Though this species is not marked by Linnæus as being represented in his collection, there exists a specimen labelled by him. It is a male with well-marked white bands.

Limenitis sibilla [1758]. Of this species there exists no example bearing a Linnean label, but one of the specimens strongly suggests a Linnean origin.

*Grapta c-album [1758]. The Linnean type belongs to the form with very dark underside; three more specimens have been added by Smith.

*Vanessa io [1751]. No specimen from the Linnean collection is now in existence.

*Vanessa antiopa [1758]. It is very likely that the typical specimen is of American origin, being small and having a narrow marginal band. Linnæus quotes America as well as Europe, showing he had received it from the New World.

*Vanessa polychloros [1758]. Linnæus's specimen is remarkably small and light-coloured on the underside.

*Vanessa urticæ [1758]. What has been said of *V. io* may be repeated here.

*Pyrameis atalanta [1758]. The example labelled by Linnæus is of the commonest form, with moderately wide crimson bands.

*Pyrameis cardui [1758]. There is nothing noteworthy about the one typical specimen.

*Araschnia levana [1758]. As in last species.

Araschnia prorsa [1758]. Linnæus describes this brood as a species distinct from *levana*, but evidently did not possess it.

*Melitæa maturna [1758]. A male and a female, unmistakably of Linnean origin. In the former bands of a fine red stand out on the lighter ground-colour of the wings.

*Melitæa cinxia [1758]. The type is a small, but brightly coloured, ♀ of the Scandinavian race, and presumably comes from the Botanical Garden of Uppsala, which Linnæus, in 'Fauna Suecica,' gives as the habitat of this species.

*Argynnis euphrosyne [1758]. One small example from the collection of Linnæus.

Argynnis dia [1767]. Described from an Austrian specimen, but not possessed by its author.

*Argynnis niobe [1758]. There exist two Linnean specimens, one of which bears a label in his handwriting. They are two males, exactly alike, and belonging to the form with no silver markings on the underside of the hind wings, except some minute specks in the pupils of the rusty spots which stretch across the wing within the light-coloured space.

If one refers to the original description we find that it exactly answers to these specimens, so that this should be considered the nimotypical form, and the name *eris*, which has so long been used for it, should be sunk in synonymy.

*Argynnis cydippe [1761] = adippe [1767]. The specimen which bears this name in Linnæus's handwriting, and which in every respect is unmistakably of Linnean origin, is a female of *A. niobe* and belongs to the so-called nimotypical form of this species with silver spots on the underside developed to the highest degree.

This startling observation enables me to point out a gross mistake made by Esper in 1777, which has been continued for nearly a century and a half. Linnæus's description agrees in every respect with the specimen labelled by him "*cydippe*" (a name which he changed in 1767 into *adippe*), but as he described this female as a species distinct from *niobe*, owing to the variability of the underside, and as his description was not accurate enough to convey exactly what he meant it for, Esper did not hesitate to attribute it to the only similar European species without a name. The result is that down to this day the latter has remained without one.

The name *syrinx* was proposed by Borkhausen for an abnormal pair figured by Esper, and the name *berecynthia* of Poda is accompanied by such a vague description that it is impossible to make out what species it is meant for ; so that, according to my view, the best plan we can adopt is to dedicate this species to the entomologist who discovered it, and name it *esperi*, taking his figures as typical.

The name *cydippe* can stand for the form of *niobe* with silver markings, and the alteration suggested by Linnæus six years after naming it had better be discarded to obviate confusion.

ARGYNNIS AGLAJA [1758]. A pale female example bears the Linnean label

*ARGYNNIS LATHONIA [1758]. The type of Linnæus belongs to the small and pale northern race.

*ARGYNNIS PAPHIA [1758]. One male specimen from the Linnean collection is unmistakably of northern origin, as may be seen by the very prominent bands and spots on the underside of the hind wings.

*MELANARGIA GALATHEA [1758]. The female labelled by Linnæus is a large example and belongs to the dark form of this species, contrasting sharply with the smaller and much lighter British race, of which specimens have been added by Smith.

*EREBIA LIGEA [1758]. Two specimens, a male and a female, are unmistakably Linnean, and obviously belong to the same race of the species, a northern one, being smallish and rather dull in colour. The female bears the name in Linnæus's handwriting. A third specimen, of the male sex, is probably also Linnean.

*SATYRUS HERMIONE [1764]. The specimen which bears this name in Linnæus's handwriting unmistakably belonged to his collection. It is a male of the species generally known as *alcyone*, Schiff., and all its distinctive characters are most prominently marked. It belongs to a Central-European race, with the white band on the upperside of the fore wings rather conspicuous and containing two ocelli. Another specimen, which is certainly also of Linnean origin, is a male of the species known as *hermione* and of a Central-European race of small size, with rather inconspicuous white bands. It is set so as to show the underside.

If we refer to Linnæus's original description we find that, on the whole, it is insufficient to enable us to make out which of these two species he meant it for (and the figures he quotes as representing his *hermione* are very good reproductions of *fidia* in one instance and of *circe* in the other !), but one character he mentions is worthy of attention : he describes the band of the underside of the fore wings as being tawny in colour ; as this is the very

character which, in a rough way, is the best to distinguish *alcyone* from *hermione,* and as the individual labelled by Linnæus possesses it to the very highest degree, there can be no doubt that that specimen actually belongs to the species Linnæus meant to describe.

If this conclusion be accepted, it is clear that *alcyone* must become synonymic of *hermione*, and that we must turn somewhere else to find the name to be adopted for the other closely allied species. It must be noted that Scopoli in 'Entomologia Carniolica' had described a *Satyrus* of this group a year before Linnæus ; but unfortunately it is utterly impossible to make out from his description which species it is, so that his name *fagi* can only be regarded as non-existing. We next come to Esper, and we find that he clearly saw the differences between the two allied species and figured them under the names of *hermione major* and *hermione minor*. The first must evidently be adopted, although it unluckily is anything but highly recommendable to stand as specific.

Satyrus fidia [1767]. Linnæus never possessed this species and never seems to have realised that Petiver's figure in 'Gazophylacium,' 12, pl. 7. fig. 5, which he quotes under *hermione,* in reality represents this insect.

Satyrus semele [1758]. Although not marked in Linnæus's copy of Syst. Nat., there exists a female specimen from his collection ; it is of the small northern race.

*Satyrus briseis [1764]. One specimen unmistakably Linnean ; it is obviously of German origin, and, in fact, that is the habitat given with the original description.

*Satyrus phædra [1764]. One Linnean male, evidently from the same locality as the last.

*Epinephile jurtina [1758]. The specimen bearing the Linnean label is a fine female of the North-African race, usually known under the name of *fortunata*, Alph.

As this name stands in Syst. Nat. before *janira*, Staudinger has done well to point out that, according to the accepted rules, it has the right of priority, but, now we know that the type is of African origin, we must furthermore add that this race should be considered as nimotypical and Alpheraky's name sunk in synonymy ; it must also be noted that Linnæus gives Africa as well as Europe as habitat of *jurtina*, showing he knew of females from both localities.

*Epinephile janira [1758]. The insect labelled by Linnæus is a small male of the preceding species with very inconspicuous apical ocellus and no trace

of tawny band on the upperside. It obviously belongs to the Central-European race, and this view is confirmed by the fact that Europe is the only locality given, proving that Linnæus had never received any males from Africa†.

We can thus come to the conclusion that the name *janira* should be used to designate the European race of *jurtina*, taking as typical of the former the Central-European one.

Epinephile tithonus [1771]. No specimen of Linnean origin of this species, which was described in 'Mantissa Plantarum,' p. 537, from specimens of a German race.

[*Pararge dejanira [1764]. A male of this species, over which Scopoli has a right of priority, having described it in 1763 under the name of *achine*.]

Pararge ægeria [1758]. Linnæus does not seem to have possessed this species, for which he gives Southern Europe and Africa as habitat.

Pararge megera [1767]. There seems to be some confusion in the Linnean collection concerning these two species: a female specimen of *megera* seems quite Linnean and bears a label on which "17 æger." is written in his handwriting; another label in Smith's handwriting points out the mistake, about which there can be no doubt, as the original descriptions of the two species are quite clear. Austria and Dania are given as localities for *megera*.

Pararge maera [1758]. This species is not marked as having been represented in Linnæus's collection, but four specimens are unmistakably of Linnean origin. Furthermore, one of them, a female, bears a label with this name in his own handwriting; another, a male, bears the name *philippus* traced by the same hand, and is set so as to show the underside—the latter name does not appear in any of Linnæus's works; a third specimen is a female exactly similar to the first, and the fourth is a male of the species which Fabricius described later as *hiera*—these two examples have no label.

The three *maera* just mentioned are quite typical of the very definitely distinct race which flies in Scandinavia: small size; no trace of tawny band in the male, very rudimentary (if present at all) in the female; underside of fore wings entirely chocolate-brown with a small patch of deep mahogany-red, that of hind wings abundantly suffused with dark shadings; on the whole, this race looks much more similar to *hiera* than it does to other *maera*, and

† This was probably the principal cause which led him to describe them as a distinct species.

it would be nearly impossible to separate them in some cases if it were not for the characters of the central streak of the fore wings. The Central-European forms having always been regarded as nimotypical of the species, Schilde suggested distinguishing the Scandinavian one by the name of *monotonia*. Here, as in other instances, it would be wise to settle nomenclature once for all on the base of positive facts; so I suggest abolishing the latter name and giving one to the race from Central and Southern Europe which is exactly intermediate between the two extreme variations of the species—the Linnean and *adrasta*. It is by far the most widely distributed of the three, and even within its range interesting local races can be detected; so, to fix it more exactly, I propose to take as typical of my *vulgaris* that which flies in the neighbourhood of Florence (Italy). It is not so large as some of the Alpine races, but it has the advantage of being very constant. The male has traces of a tawny band above, the female has one constantly, and generally also a small indefinite patch of the same colour within its inner margin; the underside of fore wings has a uniform tawny ground-colour, and the hind wings a clear uniform grey one, on which the transverse stripes stand out well. All these characters contrast with those of the Linnean race.

*Aphanthopus hyperanthus [1758]. A male and a female from Linnæus's collection are of the small form with smallish ocelli.

*Cœnonympha pamphilus [1758]. Two Linnean specimens of the small northern race, with hind wings dark on the underside and bearing a well-marked white band.

Cœnonympha hero [1761]. Not possessed by Linnæus. Sweden given as the habitat.

Cœnonympha arcanius [1761]. Though not marked as possessed by Linnæus, there are two specimens which unmistakably come from his collection, and one bears a label of his. They belong to a very small northern race and are presumably Scandinavian. The marginal black bands of wings are very wide; on the underside the white band of hind wings is narrow and the ocelli small.

*Nemeobius lucina [1758]. Two Linnean specimens.

*Thecla pruni [1758]. One male bearing the Linnean label; it is of the form with only one small orange lunule near anal angle of hind wings on upperside and with a narrow orange band on underside. Another specimen, which is evidently from the collection of Linnæus, is a *T. ilicis* with orange patch on fore wing; he probably took it to be specifically identical with *pruni*.

*Zephyrus betulæ [1758]. The example labelled by Linnæus is a female with a large orange patch on fore wings; a male specimen is unmistakably Linnean as well.

*Zephyrus quercus [1758]. A male from the Linnean collection is evidently of European origin.

*Callophrys rubi [1758]. The one Linnean specimen is a female, unmistakably of the northern race, as may be seen by its small size, dark underside, and chiefly by the complete absence of any white streak.

Thus the names of *borealis*, Krul., and *polaris*, Möschl., by which this race had been distinguished, have no reason to exist; and, assuming it to be the nimotypical one, it is the race commonly distributed in Central and part of Southern Europe which should be designated by a name: that of *virgatus* seems to me appropriate for it. Its characters are intermediate between the Linnean race and those of *fervida*, Stdgr., from the warmest portions of the habitat of *rubi*. The names *immaculata*, Fuchs, and *punctata*, Tutt, are useful to indicate its extreme individual variations.

*Chrysophanus virgaureæ [1758]. Three Linnean examples, of which one bears a label. They belong to a small and pale northern race, with markings on the underside very reduced in size and number.

The habitat given by Linnæus being Westmania, there is little doubt that these specimens are from that locality. As in the case of the European *Parnassii*, &c., it will probably be found convenient to separate from this distinct northern race that of the mountains of Central Europe, always distinguishable by its larger size, much brighter colouring, and more prominent markings of underside; the male on upperside has a richer redder tone than is ever the case in Scandinavia. I propose for it the name of *inalpinus*. I think the name of *oranula*, given by Freyer to the extreme northern form from Lapland, can be preserved, as that race is not identical with the nimotypical one, being still smaller and paler. The race which stands furthermost from the latter is, to my knowledge, the large and boldly marked *virgaureæ* of the Maritime Alps in Piedmont (Valdieri, 1400 m.); so it might be taken as typical of *inalpinus*.

*Chrysophanus hippothoë [1761]. The two Linnean specimens in existence are males of the species which is generally known under this name. They evidently belong to a northern race and are presumably Scandinavian, as Linnæus describes this species in 'Fauna Suecica.' They present characters intermediate between those of the form which is generally considered as nimotypical and the characters of the Alpine form *eurybia*, Ochs., agreeing with the latter by their small size, dull colouring, and diffused black shadings,

and with the former by the presence of a small amount of violet scaling along the costal margin. The specimen which bears the label of Linnæus is an aberrant one : on the underside of both fore and hind wings the two series of ocelli which precede the submarginal orange band are confluent, and give rise to a single series of wedge-shaped streaks, as in the specimen figured by Gerhard under the name of ab. *confluens*.

The fact that we have the Linnean type of this species under our eyes is very interesting, because it had been held in doubt by many entomologists whether the species which is generally known as *hippothoë* was really that which Linnæus intended to describe, and whether it was not more likely to be *C. dispar*. The point of this controversy is now evidently settled.

An error of secondary importance, which, however, I think it would be well to rectify once for all, as in the case of other species, is that regarding the nimotypical race. The Central-European one has always been regarded as such, and, accordingly, *eurybia* from the higher Alpine ranges and *stieberi* from Lapland had been described as varietal forms. On the contrary, we now know that Linnæus's types are identical with the latter and nearer allies to the former than to what was considered the nimotypical form ; so that the most beautiful and highly specialised race of *hippothoë* in which both sexes are vividly coloured—the male being of a very bright reddish copper on upperside with a strong purple gloss, and presenting a distinct orange submarginal band on underside—has to this day remained unnamed. I propose the name of *mirus*, taking as typical of it the race which flies in the Pyrenees and which is quite similar also to the German one (Cassel, Berlin, etc.) ; to my knowledge it is furthest removed from *eurybia*.

*Chrysophanus phlæas [1761]. No Linnean specimen in existence now.

Lampides bœticus [1767]. Linnæus gives Barbaria as habitat for this species, but it was not represented in his collection.

*Lycæna argus [1758]. Two male specimens of Linnean origin, one of which is labelled. They are large, brightly coloured, and very white on underside, and belong to the species to which Staudinger and most previous authors rightly attribute this name.

Few species have been the object of longer debates amongst naturalists than this and the following. These are the only Linnean types, strange as it may seem, which any entomologist has referred to in a direct way, to settle definitely the controversies caused by the insufficiency of original descriptions. Tutt, in fact, examined the two insects, and placed his conclusions before the Entomological Society of London in the meeting of the 17th of March, 1909. I can in this case fully agree with them. As regards

the following species, he seems to have overlooked some facts on which I wish to lay particular stress.

Lycæna idas [1761]. This insect is not marked by Linnæus in his copy of the XII. edit. of Syst. Nat., because he only quotes it in that work as a synonym of *argus*. There exist, however, two specimens which are unmistakably Linnean. The one which now bears his label is a female with wings entirely brown and one fulvous lunule near anal angle. It is unfortunately one of those specimens of this sex which it is very difficult, if not impossible, to refer with certainty to *argus* or to its near ally. I am personally more inclined to consider it as belonging to the latter rather than to the former. The other Linnean specimen is a most typical female of the species for which Staudinger has proposed the name of *argyrognomon*, Bergstr., and furthermore, curiously enough, it belongs to the blue form of that sex for which the name *argyrognomon* was published, and which Staudinger proposed to name *callarga*. The basal half of the wings is entirely blue, and they bear very prominent fulvous marginal lunules.

Turning our attention to the Linnean literature on the subject, we first find the name *idas* in 'Fauna Suecica' given as "nomen triviale" to the insect which Linnæus had already described before he took to the binomial nomenclature, and in the "nomen specificum" of which he clearly stated that the wings were blue with rufous marginal lunules. This brief description he transcribes in all his following works when quoting *idas*. Curiously enough, in the somewhat more lengthy one which follows it, there is an open contradiction, as it is stated that the wings are entirely brown. It seems to me that the "nomen specificum" from every point of view ought to be considered as the original description of *idas*, the more so seeing that we have before us the striking fact of the existence of the specimen for which the name was created.

Thus we are led to the conclusion that even if the brown specimen is a female of *argus*, it is the blue one which ought to be considered as the type of *idas*; and we can definitely settle the question regarding the names of the two species in a very satisfactory manner by discarding the long-debated name of *œgon*, as was suggested by Staudinger, and by re-establishing the Linnean name of *idas* in the place of *argyrognomon*, which, for several good reasons, had not been favourably accepted by most entomologists as specific.

In any case it will be found necessary to alter the name *idas* given by Rambur to a Spanish species of the same genus, and it might be dedicated to its author under that of *ramburi*.

*Lycæna arion [1758]. The Linnean specimens consist of a darkish male and of a much lighter coloured female.

*Cyaniris argiolus [1758]. The Linnean type bearing his label is a female of the spring brood, as may be seen by its small size, narrow black marginal band, and prominent spots on the underside.

*Pamphilus comma [1758]. There are three specimens from Linnæus's collection, two males and a female. One of the former and the latter unmistakably belong to the northern race, being small and dark with prominent quadrangular spaces on the underside.

*Hesperia malvæ [1758]. One Linnean male of this very constant species. It exhibits to a marked degree the characters distinguishing *malvæ* from *malvoides*, Elw. & Edw.

*Thanaos tages [1758]. The three males which evidently belonged to Linnæus are of the form with dark ground-colour, rendering the black bands and markings very inconspicuous.

Synopsis of Proposed Alterations.

Substitute:	In place of:
Papilio sinon sinon, Poda	*Papilio podalirius*, auct., *zanclaeus*, Zell.
„ „ *vernus*, nom. nov.	„ „ *podalirius*.
„ *podalirius podalirius podalirius*, L.	„ *feisthameli*, Dup., *lotteri lotteri*, Aust.
„ „ *maura*, Verity, *podalirius*, L.	„ „ *maura* „
„ „ *podalirius feisthameli*, Dup.	„ „ *feisthameli feisthameli*.
„ „ *miegi*, Thierry-M., *feisthameli*, Dup.	„ „ *miegi* „
Pieris napi napi napi, L.	*Pieris napi napi arctica*, Verity.
„ „ *vulgaris vulgaris*, nom. nov.	„ „ „ *napi*, auct.
„ „ *napææ*, Esp., *vulgaris*	„ „ *napææ napi*.
„ *rapæ rapæ rapæ*, L.	„ *rapæ metra*, Steph., *rapæ*.
„ „ *æstivus*, nom. nov., *rapæ*	„ „ *rapæ*, „
„ *brassicæ brassicæ brassicæ*, L.	„ *brassicæ chariclea*, Steph., *brassicæ*.
„ „ *lepidii*, Röb., *brassicæ*, L.	„ „ *brassicæ*, „
Euchloë belia, L.	*Euchloë eupheno*, L.
„ *crameri*, Butler	„ *belia*, Cramer.
Gonepteryx rhamni, L., *transiens*, nom. nov.	*Gonepteryx rhamni*. South-European race.
„ *cleopatra cleopatra*, L.	„ *cleopatra mauritanica*, Röb.
„ „ *europæus*, nom. nov.	„ „ *cleopatra*.
Charaxes jasius, L., *septentrionalis*, nom. nov.	*Charaxes jasius*. European race.
Apatura iris, L.	*Apatura ilia*, Schiff.
„ *pseudoiris*, nom. nov.	„ *iris*, auct.
Argynnis niobe niobe, L.	*Argynnis niobe eris*, Mieg.
„ „ *cydippe*, L.	„ „ *niobe*, auct.
„ *esperi*, nom. nov.	„ *adippe*, auct.

Substitute:	In place of:
Satyrus hermione, L.	*Satyrus alcyone*, Schiff.
„ *major*, Esp.	„ *hermione*, auct.
Epinephile jurtina jurtina, L.	*Epinephile jurtina fortunata*, Alph.
„ „ *janira*, L.	„ „ *jurtina*.
Pararge maera maera, L.	*Pararge maera monotonia*, Schilde.
„ „ *vulgaris*, nom. nov.	„ „ *maera*.
Callophrys rubi rubi, L.	*Calophrys rubi borealis*, Krul. (= *polaris*, Möschl.).
„ „ *virgatus*, nom. nov.	„ „ *rubi*.
Chrysophanus virgaureæ inalpinus, nom. nov.	*Chrysophanus virgaureæ*. Central-European race.
„ *hippothoë hippothoë*, L.	„ *hippothoë stieberi*, Ger.
„ „ *mirus*, nom. nov.	„ *hippothoë*. Central-European race.
Lycæna idas, L.	*Lycæna argyrognomon*, Bergstr.
„ *ramburi*, nom. nov.	„ *idas*, Ramb.

Observations on certain Names proposed in Dr. Verity's paper on the Rhopalocera Palæarctica in the Collection of Linnæus. By Dr. Karl Jordan. (Communicated by the President.)

[Read 1st May, 1913.]

Having had an opportunity of reading Dr. Verity's interesting and important investigation of the Linnean Palæarctic butterflies, I should be glad to make a few observations concerning the names proposed by that author in substitution of those now in currency.

It must be admitted that the Linnean specimens are of great historical interest, and Dr. Verity knows the Palæarctic butterflies so well, that his identifications of the Linnean specimens may be accepted as perfectly correct, and the specimens and labels claimed to be Linnean by Dr. Verity may be regarded as undoubtedly genuine.

On the other hand, there is no proof positive that these specimens are those from which Linnæus drew up the descriptions for the 'Syst. Nat.' ed. X. (1758); in the absence of such proofs we cannot follow Dr. Verity in according them the status of "types."

The utmost care and circumspection should be exercised before a change of name is proposed, and if there is any doubt as to the necessity of the change, no change should be made. Even if the Linnean specimens could be proved to be "types," some of the changes in nomenclature proposed by Dr. Verity would nevertheless be unwarranted and would give rise to just and strong protests, *e. g.* in the case of *Papilio podalirius*. Three examples different in character may suffice as a criticism of Dr. Verity's arguments.

a. *Papilio podalirius*.—The name was based by Linnæus in 1758 on recognisable figures of the Central European Scarce Swallowtail. It is entirely indifferent from a nomenclatorial point of view whether Linnæus had seen a specimen or not. Names are frequently being proposed for species known to the author only from figures or descriptions, and such names are valid.

b. *Apatura iris*.—The *iris* of 1758 is composed of two species, one bearing an ocellus both on the fore and the hind wing, and the other species having a distinct ocellus only on the hind wing. The description of 1758 only mentions the ocellus of the hind wing, and therefore applies strictly to the species generally known as *iris*. Moreover, in the case of composite species any subsequent author is at liberty to restrict the name to one of the species. This was done in 1776 by Schiffermüller, who gave the name of *ilia* to the bi-ocellate species. It is entirely indifferent from a nomenclatorial point of view that Linnæus has added a manuscript note to the original

description. This note—posterior to 1758, and to the effect that *iris* has an ocellus on both wings—may, however, be taken as evidence that Linnæus received specimens of the bi-ocellate species after 1758.

c. *Argynnis adippe*.—The Linnean description applies equally well to the silver-spotted form of *niobe* as to the insect generally known as *adippe* (=*cydippe* preocc.), although Esper (in 1782) was emphatic on the point that the description best fitted the species he figured as *adippe*. If the female from the Linnean collection can be proved to be the one on which the name *cydippe* was based in 1761, a change of name would be necessary in accordance with the law of strict priority. That proof it will be difficult or impossible to furnish, and some doubt will remain as to whether Esper in 1782 was really wrong in figuring as *adippe* L. the insect known under that name ever since.

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On the Classification of the Order Symphyla.

By Richard S. Bagnall, F.L.S., F.E.S.
(Hope Dept. of Zoology, University Museum, Oxford.)

[Read 3rd April, 1913.]

As far back as 1882, in a note on the "Genera of the Scolopendrellidæ,"* J. A. Ryder shows that there are two forms, stating that "the first has the body very slender, tapering anteriorly, with the eyes or stemmata placed on the upper surface of the narrow, elongate head; the second form has a broader, more robust body of nearly uniform width anteriorly and posteriorly, with the eyes or stemmata at the sides of the head and not visible from above, the head itself being nearly circular or sub-quadrate in outline from above.

"The first is the type to which we may assign the old designation of *Scolopendrella* originally proposed for it by Gervais †; the second, of which Newport's species (i. e., *immaculata*) becomes the type, may be distinguished generically from the first, as pointed out above, under the name of *Scutigerella*. The latter form is also distinguished from the first by the much greater development of the basal appendages of the legs."

Hansen ‡, in his excellent 'Monograph of the Order Symphyla' (established as an order by Ryder in 1880) says (p. 23): "The group consists of one single family with two genera," but in a footnote he adds, with some significance, "Some zoologist will perhaps soon establish these genera as families, and divide each of them into two or more genera."

Since Hansen's work was published in 1904 single species have been described by Imms, Silvestri, and Attems, whilst I have had the pleasure of examining very rich English material comprising no less than fourteen species and have just received numerous tubes of Oriental material.

Prior to the appearance of Hansen's monograph Silvestri § diagnosed a new genus, *Symphylella*, for the species of *Scolopendrella* in which the first pair of legs is absent, with *isabellæ*, Grassi, as type. He also figured and described *Scolopendrella notacantha*, Gervais, and *S. pygmæa*, sp. n., species which agree in the possession of the first pair of legs, but which in my opinion are more strongly separated than *pygmæa* and *isabellæ*. This paper was not noticed by Hansen, and I am inclined to think that *Scol. subnuda*, Hansen, will prove to be synonymous with *S. pygmæa*, Silvestri.

In working out my material I have come to the conclusion that the genera *Scutigerella* and *Scolopendrella* as diagnosed by Hansen represent two

* Proc. U.S. Nat. Mus. v. (1882) p. 235.

† Ann. Sci. Nat. sér. 3, Zool. ii., 1844.

‡ "The Genera and Species of the Order Symphyla," Quart. Journ. Micr. Sci. xlvii., 1904.

§ In Berlese's 'Acari, Myriop. et Scorp. huc. in Italia rep.,' fasc. xcvi., 1902.

main groups, here treated as subfamilies but which might in future be readily given family rank, and that each contains at least three strongly characterized genera.

In the Scutigerellinæ (as I propose to name the first group) I was fortunate enough to collect two new species of the *immaculata*-group, which makes it safe to deal with *immaculata* as a type distinct from the *nivea*-group. In fact, although Hansen (*in litt.*) has always regarded *Scutigerella* as more difficult to deal with than *Scolopendrella*, this material has enabled me to tabulate the genera of the Scutigerellinæ in unmistakable characters.

In *Scutigerella*, s. str., the postero-median cavity of the last dorsal scutum is peculiar and is endorsed by the absence of the long outstanding antero-lateral or lateral scutular setæ. In this genus we find two species each possessing a distinctive character which does not reappear in succeeding groups,—*armata*, Hansen, having each fore-femur armed with a distinct tooth, and *biscutata*, Bagn., possessing a pair of plate-like prolongations hinged to the 13th dorsal scutum.

The second genus, *Neoscutigerella*, is erected for the English species *S. Hanseni*, Bagn., and in the character of its scutular setæ stands alone. The absence of the postero-median cavity of the last abdominal setæ precludes its reception in the genus *Scutigerella*, but here, too, the possession of longer, outstanding, and presumably sensory setæ is not shown. A second species of this genus (from Ceylon) is in my possession.

In the third and last genus, *Hanseniella*, the long outstanding setæ of the scuta appear for the first time, and this feature is continued throughout the genus and throughout the genera of the second subfamily, Scolopendrellinæ. In the subgenus *Scolopendrelloides* (which may ultimately be split off from *Hanseniella*, s. str.), as exemplified by two species, we find three common characteristics of which two are noteworthy. Firstly the somewhat deep postero-median depressions of the last scutum suggests the curious cavity in *Scutigerella*, whilst the shorter exopods of the posterior legs lead one naturally to the Scolopendrellinæ.

Scolopendrella, s. str., in the well-developed legs of the first pair present a connecting link also, and this pair in the next genus, *Scolopendrellopsis*, is there also but smaller, and in *Symphylella* is obsolete. Whilst I have accepted Silvestri's genus *Symphylella*, I should here point out that as yet I have not succeeded in perceiving any valuable character other than the absence of its first pair of legs to warrant its separation from *Scolopendrellopsis* (but I have only examined the one species *subnuda*, Hansen), whilst from my table it will be seen that these genera cannot possibly be included in the genus *Scolopendrella*, being separated by the strongest morphological characters.

I name the genus *Hanseniella* in honour of one of our foremost zoologists, Dr. H. J. Hansen, of Copenhagen, whose friendship and help I am proud to acknowledge.

Family Scolopendrellidæ.

Species usually larger and more robust, with the first pair of legs always well developed and more than half the length of the following pair; the exopods well developed and conspicuous.

Posterior margins of all the dorsal scuta but the last slightly rounded or emarginate, with angles generally broadly rounded, rarely angular (but when angular each lobe is several times broader than long).

Dorsal surface of the hind pair of legs usually furnished with numerous setæ. Cerci simple, that is, without striped terminal area or transverse lines at apex..... Subfamily Scutigerellinæ, mihi.

2. Species smaller and more slender, with the legs of the first pair rarely more than one-half the length of those of the following pair (*S. notacantha* is the only exception), and more usually vestigial; none of the exopods well developed.

Posterior margins of all the dorsal scuta but the last one produced into a pair of triangular plates.

Dorsal surface of the hind pair of legs furnished with very few setæ. Cerci usually with a striped terminal area, and often, in addition, with raised transverse lines on the most distal part outside the area.

Subfamily Scolopendrellinæ, mihi.

Subfamily Scutigerellinæ, mihi.

1. Last dorsal scutum with a very deep and somewhat large cavity overlapped anteriorly and situated in the middle of the posterior margin. No long outstanding setæ on lateral margins of scuta Genus Scutigerella, Ryder.

Last dorsal scutum without such median cavity..... 2.

2. All setæ on scuta, excepting an antero-marginal pair on the first scutum, short, blunt, and fusiform Genus Neoscutigerella, nov.

All setæ normal. The second scutum (and certain others) furnished with at least one pair of longer, forwardly or laterally directed, latero-marginal setæ Genus Hanseniella, nov.

a. The last scutum slightly depressed posteriorly along the middle. The exopods of posterior legs well developed. The setæ on the inner side of the proximal antennal joints directed obliquely forwards and, at most, about one and one-half times as long as the setæ on the outer side Subgenus Hanseniella, s. str.

b. The last scutum with a deep postero-median depression. The exopods of posterior legs short, at most much shorter than the depth of tarsus. Some setæ on the inner side of the proximal antennal joints nearly vertical to the longitudinal axis of the antennæ and unusually long, the longest at least two and one-half times as long as the setæ on the outer side Subgenus Scolopendrelloides, nov.

Subfamily SCOLOPENDRELLINÆ, mihi.

1. First pair of legs well-developed, of normal shape and more than two-thirds the length of the following pair. Hind margin of each scutum with a distinct longitudinally striate belt between the pair of triangular processes. Cerci without the raised transverse lines at the most distal part. Central cephalic rod interrupted before the middle and there branching shortly to either side Genus SCOLOPENDRELLA, Gervais.

 First pair of legs reduced in size or (more usually) obsolete. Hind margins of scuta without striate belts. Cerci with raised transverse lines at the most distal part opposite to the terminal area. Central cephalic rod interrupted before the middle, but not branched laterally 2.

2. First pair of legs present, not more than one-half the length of the following pair Genus SCOLOPENDRELLOPSIS, nov.

 First pair of legs obsolete, represented by a pair of rudimentary wart-like protuberances, without claws even..... Genus SYMPHYLELLA, Silv.

Species of the Order SYMPHYLA.

Subfamily SCUTIGERELLINÆ, Bagnall.

Genus SCUTIGERELLA, Ryder.

Species IMMACULATA (Newp.), *armata*, Hansen, *spinipes*, Bagn., and *biscutata*, Bagnall.

Genus NEOSCUTIGERELLA, Bagnall.

Species HANSENI (Bagn.).

Genus HANSENIELLA, Bagnall.

Subgenus HANSENIELLA, s. str.

Species *unguiculata* (Hansen) *, *subunguiculata* (Imms) †, *caldaria* (Hansen), *orientalis* (Hansen), *plebeia* (Hansen), *ruwenzorii* (Silvestri) ‡, NIVEA (Scop.), *chilensis* (Hansen), *capensis* (Hansen), and *angulosa* (Hansen).

Subgenus SCOLOPENDRELLOIDES, Bagnall.

Species CRASSICORNIS (Hansen), and *pauperata* (Hansen).

* Gravely names a subspecies *indica*, of which I shall have something to say later.

† Journ. Linn. Soc. Lond., Zool. xxx., 1909.

‡ Torino Boll. Mus. Zool. ed. Anat. vol. xxii., 1907. I have not yet seen the description.

Subfamily SCOLOPENDRELLINÆ, Bagnall.

Genus SCOLOPENDRELLA, Gervais.

Species NOTACANTHA, Gervais.

Genus SCOLOPENDRELLOPSIS, Bagnall.

Species MICROCOLPA (Muhr), *pygmæa* (Silv.), *sulnuda* (Hansen) *, and *silvestrii* (Hansen).

Genus SYMPHYLELLA, Silvestri.

Species ISABELLÆ (Grassi), *dunelmensis* (Bagn.), *jacksoni* (Bagn.), *texana* (Hansen), *vulgaris* (Hansen), *horrida* (Bagn.), *neotropica* (Hansen), *simplex* (Hansen), *delicatula* (Bagn.), *minutissima* (Bagn.), *pusilla* (Hansen), *brevipes* (Hansen), and *antennata* (Hansen).

* Perhaps synonymous with *pygmæa*.

[NOTE.—I have not seen Graf Attems' description of his *Scutigerella indecisa* from South-West Australia, and have therefore been unable to include it in the above list.—R. S. B., 23rd July, 1913.]

Freshwater Rhizopoda from North and South America.

By G. H. Wailes, F.L.S.

(Plate 15.)

[Read 19th June, 1913.]

UNITED STATES.

During the year 1912 I was able to augment the records of Rhizopoda from the Eastern United States, described in a paper read before this Society in April 1912 *, by collections from the following localities :—

New Jersey.—The Palisades on the west bank of the Hudson River from opposite Yonkers for about 5 miles southward ; gatherings from pools, moss, and sphagnum. This district dries up almost completely during the summer, but 99 species and varieties were recorded, including *Difflugia oviformis*, *D. rubescens*, *Nebela caudata*, *N. tenella*, *Euglypha crenulata*, *E. alveolata* var. *cirrata*, and *Cryptodifflugia eboracensis*, besides others noticed at greater length below.

Englewood and Leonia ; gatherings from pools, ditches, etc., and a large swamp forming part of the Hackensack Meadows : from this district 41 species were obtained, including *Nebela dentistoma* var. *lacustris*, *Euglypha alveolata* var. *cirrata*, and *Pseudodifflugia fulva*.

Princeton ; squeezings from water-plants and sediment from Carnegie Lake, sphagnum from a marsh about one mile north of the lake, and gatherings from a pond near Rahway : 57 species were obtained, including *Difflugia oblonga* var. *cornuta*, *D. oviformis*, *D. rubescens*, *D. urceolata*, *Nebela scutellata*, *Euglypha alveolata* var. *cirrata*, and *Pseudodifflugia gracilis*.

New York State.—West Point on the Hudson ; gatherings from a lake and small marsh, from which 28 species were obtained, including *Bullinula indica*, *Euglypha rotunda*, and *Pseudodifflugia fulva*.

Baldwin, Long Island ; gatherings from a large pond having sphagnum and *Drosera rotundifolia* growing on the margin : 39 species were recorded, including *Pseudodifflugia Archeri* and *P. gracilis* ; *Difflugia rubescens* and *Cyphoderia trochus* var. *amphoralis* were particularly numerous.

Virginia.—Ocean View near Norfolk ; two gatherings of water-plants and some sediment collected by E. Solomonsky ; from these 44 species were

* Journ. Linn. Soc., Zool. xxxii. (1912) pp. 121–161.

obtained, including *Difflugia oviformis*, *D. tuberculata* and var. *minor*, only one species of *Nebela*—*N. barbata*, *Euglypha alveolata* var. *cirrata*, *E. armata*, *E. crenulata*, *E. rotunda*, and *Pseudodifflugia gracilis*. Especially numerous was a handsome form of *Centropyxis aculeata* var. *discoides*, about 200 μ in diameter, having a brown test with usually three spines.

The above localities and a further examination of previous collections added 24 species and varieties to the 161 previously recorded, including three new species and one new variety. Short notes on these additional records are added.

Sub-Class **RHIZOPODA.**

Order AMŒBINA.

Family Lobosa.

Amœba pilosa, *Cash.*

Linn. Soc. Journ., Zool. xxix. (1904) p. 219. pl. 26. fig. 8.
Cash & Hopkinson, Brit. Freshw. Rhiz., Ray Soc., i. (1905) p. 62, pl. 4. figs. 1–5.

Two individuals of this species were obtained in Van Cortlandt Park, N.Y.; when inactive they were about 50 μ in diameter and covered with fine cils 6 μ in length; the endoplasm was loaded with various kinds of granules, including green and yellow bodies; two rather small contractile vacuoles were visible near the periphery, but the nucleus could not be distinguished. When in movement the ectoplasm flowed in short lobular expansions, the surfaces of which became immediately covered with the fine cils. Whilst under observation one individual rejected all the granular inclusions, leaving a finely granular grey plasma which completely dispersed immediately on becoming dry.

Amœba proteus var. granulosa, *Cash.*

Cash & Hopkinson, Brit. Freshw. Rhiz., Ray Soc., i. (1905) p. 48, pl. 1. fig. 3; pl. 3. fig. 2.
Amœba proteus pars, Leidy (**6**), p. 30, pl. 1. fig. 4.

Occurs on the Palisades, N.J. One individual measured 600 μ in length and about 90 μ in breadth, when active.

Amœba villosa, *Wallich.*

Leidy (**6**), p. 62, pl. 2. figs. 14–16; pl. 8. figs. 1–16.

Not uncommon on the Palisades. Albany, N.Y. (*De Tarr*).

Family Vampyrellida.

Vampyrella lateritia (*Fresen.*), *Leidy*.

Leidy (**6**), p. 253, pl. 45. figs. 10–16.
Vampyrella spirogyræ, Cienk. in Arch. mikr. Anat. i. (1865) p. 218, pls. 12, 13. figs. 44–65.

At West Point, N.Y., and in a pool on the Palisades, N.J., opposite Harlem, this species occurs numerously. Individuals kept under observation fed freely on filaments of *Spirogyra* (cells 30 μ diam. and 70–80 μ in length); the contents were abstracted by the animal apparently dissolving an oval aperture, 10–12 μ in length, in the cell-wall; through this, pseudopodia were thrust and the cell-contents absorbed, then the transverse cell-walls were attacked, and a very small hole, about 2 μ in diameter, was made in each by the extremity of a pseudopodium which was then used to abstract such of the contents as were within its reach, a portion usually being left. After three adjoining cells had thus been more or less completely emptied, the *Vampyrella* moved along the filament for a distance of 3 or 4 cell-lengths and repeated the process. Whilst feeding, the animals did not increase noticeably in size but became green; this colour, however, soon disappeared, and the normal brick-red colour was resumed.

Frequently accompanying the *Vampyrellæ* were a number, 4 to 8, of small amœboid sporozoa, 6 to 8 μ in diameter; they appeared to search the *Spirogyra* filament for the large openings made by the *Vampyrella*, through these they entered the empty cells and then searched the end walls for the small perforations that had been made, squeezed themselves through, and fed on such portions of the contents of the cells as had been beyond the reach of the *Vampyrella*. These sporozoa had a well-defined nucleus and small vacuole, whilst within the cells they displayed two or three sharply pointed pseudopodia; they became green and larger after feeding, and frequently some were unable to emerge through the small perforation until the process of digestion had reduced them in size.

Order CONCHULINA.

Family Arcellida.

Arcella curvata, sp. nov. (Pl. **15**. figs. 3 & 4.)

Arcella discoides pars, Leidy (**6**), p. 173, pl. 28. figs. 32–36.

Test of medium size, light brown in colour, circular, the ventral face curved so as to form a portion of a cylindrical surface subtending an angle of 80°–100°, the dorsal face forming a dome of moderate height; aperture large, circular, invaginated, bordered by numerous small pores; plasma greyish, granular, usually including many food-particles; the nuclei not

large, about four or five in number ; two or more contractile vesicles usually present ; pseudopodia not observed.

Diameter 120–135 μ ; aperture 48–55 μ ; thickness about one quarter of the diameter.

Distribution.—Norfolk, Virginia ; Jacksonville, Florida (*Leidy*) ; Switzerland (*Penard*).

In the material from Norfolk the curved tests at once attracted attention, and that this is not merely an accidental condition is evidenced by the constant curvature and the absence of any similar tests not curved. The number of the nuclei also distinguishes it from other *Arcellæ*, a subject which is entered upon at greater length in the note on the following species.

No active and only a few living individuals were observed, and further observations as to the number of nuclei and the plasma, etc., are desirable. Penard has observed this species in two localities near Geneva ; at Norfolk it occurs numerously but is perhaps of very local occurrence.

ARCELLA MEGASTOMA, *Penard*, sp. nov. (Pl. **15**. figs. 1 & 2.)

A. polypora pars, Penard (**8**), p. 408.
A. polypora pars, Wailes (**16**), p. 130.
A. discoides, Ehrenb. pars, Leidy (**6**), p. 173, pl. 28. fig. 22.

Test large, circular, compressed, thickness about one quarter to one third of the diameter ; aperture large, circular, invaginated, surrounded by numerous small pores, from 0·4 to more than 0·5 of the diameter of the test in width ; plasma greyish in colour, granular, attached to the test by numerous epodes and containing many food-particles ; nuclei small, numerous, from 40 to 200 in number ; several contractile vesicles usually present ; pseudopodia digitate.

Diameter 190–365 μ ; aperture 100–190 μ.

Distribution.—Van Cortlandt Park, N.Y.; Split Rock, Lake Boonton, N.J.; Wyoming (*Leidy*); Chili ; Switzerland (*Penard*).

Having received slides containing specimens found near Geneva, kindly sent to me, for comparison with American specimens, by Dr. Penard, he suggested that I should give a description of this species, which he had named provisionally *A. megastoma* ; it is, however, to be hoped that he will supplement it by the results of observations extending over a considerable period.

All species of *Arcellæ* have normally two nuclei only, except *A. polypora*, *A. megastoma*, and *A. curvata* ; the first two belong to what may be called the *A. discoides* group, having tests more or less similar to that species but possessing more than two nuclei : *A. discoides*, however, has been recorded by several observers with more than two nuclei (**8**. p. 408), for example Leidy (**6**), Pl. 28. fig. 28, shows a test 180 μ in diameter with three nuclei, but others may have escaped observation, and in other respects it conforms to *A. polypora* ;

but until a sufficient number of observations have been recorded to clear up this question it would perhaps be advisable to regard *A. polypora*, Penard, as a variety of *A. discoides*, Ehrenberg. The following table shows the relationship of these species with *approximate* limits of size :—

	Diameter.	Aperture.	Height.	No. of nuclei.
Arcella discoides, Ehrenberg	80–150 μ	·3 dia.	1/5 to 1/3 dia.	2 normally
„ *polypora*, Penard	100–200 μ	·3–·4 dia.	1/4 to 1/3 „	8-20
„ *megastoma*, Penard, sp. nov.	190–365 μ	·4–·55 dia.	1/4 to 1/3 „	40–200
„ *curvata*, sp. nov.....	120–135 μ	·4 dia.	1/4 dia.	4 or 5

Information is required regarding the development of the young of the above species and the number of nuclei present at various stages of their growth. It is possible that the nuclei increase in number by division during the development of an individual. The structure of the tests and the pores around the apertures appear to vary in the *A. discoides* group within a wide range, the limits of which cannot at present be accurately defined.

Arcella vulgaris, *Ehrenberg*. (Pl. **15**. fig. 5.)

An unusual form of this species was found which has acute basal angles, as shown in fig. 5.

Diameter 100–136 μ ; height $\frac{1}{3}$ to $\frac{1}{2}$ the diameter.

Distribution.—Princeton, N.J.; Norfolk, Va.

Family Difflugina.

Difflugia bicornis, *Penard*, *in Mém. Soc. Genève*, xxxi. 1890, no. 2, p. 141, pl. 4. figs. 12–14. (Pl. **15**. figs. 10 & 11.)

D. bicuspidata, Rhumbler, Zeitschr. f. wiss. Zool. lii. (1891) p. 546, pl. 32. fig. 60.
D. elegans pars, Penard (**8**), p. 237, fig. 10.
? *D. acuminata* pars, Leidy (**6**), p. 109, pl. 12. figs. 24–27.

The majority of the tests observed were furnished with two horns, but three- and rarely four-horned tests also occur ; the two- and three-horned forms are symmetrical, but the fourth horn appears as if interpolated on the latter form (fig. 11).

Length, without horns, 70–80 μ ; breadth of test 60–65 μ; horns 20–30 μ in length.

Distribution.—Good Ground, Long Island; Palisades and Princeton, N.J.; Asbury Park, N.J.

The tests figured by Leidy (figs. 24–27) have smaller and less divergent horns than those seen by me but are of about the same size, his figs. 28 and 29 are much larger (about 200 μ in length).

This species is much smaller than either *D. corona* or *D. urceolata*, has fewer horns, and the circular aperture is devoid of any lip. The plasma often contains zoochlorella cells.

Difflugia lanceolata, *Penard.*

D. pyriformis pars, Leidy (**6**), p. 98, pl. 10. fig. 17.

Occurs on the Palisades, N.J., about 140 μ in length.

Difflugia olliformis, *Lagerheim.* (Pl. **15**. fig. 12.)

In Förh. Geol. Fören. Stockholm, xxiii. (1901) p. 512, figs. 1–5.

The test of this *Difflugia* resembles that of *D. subæqualis*, Penard (Revue Suisse), but is rarely so large, is less truncate and much more variable in size. The colour of the test is brown, with an aperture bordered by a collar usually smooth but occasionally composed of small grains loosely aggregated.

Length 80–87 μ ; diameter 70–78 μ ; collar 36–42 μ.

Distribution.—Carnegie Lake, Princeton, N.J.

In the 'Scottish Naturalist,' March 1912, p. 63, this species was recorded doubtfully by me as *D. subæqualis*. The limits of size in Great Britain are:—length 50–84 μ, diameter 45–80 μ, collar 30–60 μ. A small variety about 30 μ in length also occurs in Yorkshire (Lagerheim, figs. 4 & 5).

Difflugia urceolata var. amphora, *Leidy.*

Leidy (**6**), pl. 14. figs. 3, 4, 8; pl. 16. fig. 34.

D. amphora, Leidy, Proc. Acad. Nat. Sci. Philad. 1874, p. 79.

This variety is distinct from *D. amphora*, Penard (Faune Rhiz. Léman, 1902), which is distinguished by a recess around the base of the neck, and the collar having in side view a wavy outline, and by the expression of the polygonal aperture. *D. amphoralis*, Hopkinson, is a much smaller species.

Length 190–200 μ (Leidy 200–600 μ) ; diameter 125–128 μ ; aperture 58–60 μ. Similar to Leidy's fig. 8, pl. 14.

Distribution.—Van Cortlandt Park, N.Y.

Family Nebelina.

Nebela saccifera, sp. nov. (Pl. **15**. figs. 7, 8, 9.)

Difflugia equicalceus pars, Leidy, Proc. Acad. Nat. Sci. Philad. 1874, p. 156.

Nebela equicalceus pars, Leidy, *ibid.* 1876, p. 118, fig. 15.

Nebela equicalceus, Wailes (**16**), p. 137.

Nebela hippocrepis pars, Leidy (**6**), p. 156, pl. 24. fig. 13.

Test of large size, pyriform, compressed, colourless, formed of circular discs usually imbricated ; provided with two hollow curved horns, projecting

internally, arising at each side of the test above the widest part, and communicating at the base with the exterior by a small slit-like orifice; test in lateral view narrowly pyriform; transverse section elliptical, prolonged at each end into a shallow keel; aperture elliptical; nucleus large, placed posteriorly, containing several nucleoles; plasma normal.

Length 203–240 μ; breadth 126–145 μ; aperture 38–45 μ by 20–23 μ; thickness one half to two thirds of the breadth; length of horns 35–60 μ.

Habitat. Sphagnum.

Distribution.—Lakehurst; Absecom (*Leidy*), N.J.; Good Ground, Long Island (16).

Leidy found only two empty tests of this species, and he realised that although related to, they were distinct from *Nebela equicalceus*; from which species it is distinguished by the absence of the horseshoe-shaped keel around the fundus, by the horns not being solid, and the smaller size of the test with a shorter neck. The small openings at the base of the horns are very narrow slits usually indistinguishable but readily detected if a test be removed from water into oil of cloves, when the oil can be seen entering through them: although not uncommon in several gatherings and many living individuals were seen, none were active. No specimens of *N. equicalceus* were found. It may perhaps be more than a coincidence that if the space occupied by the horns were vacant the test would then be similar to that of *N. ansata*, and the small discs often attached to the horns of that species (Leidy, Pl. 25. fig. 1) may represent the discarded material.

Cochliopodium echinatum, *Korotneff*.

In Arch. Zool. expér. viii. (1879) p. 480, pl. 25. fig. 9.

C. vestitum pars, Leidy (6), p. 188, pl. 32. figs. 27, 28.

A form occurs at Good Ground, Long Island, similar to Leidy's figs. 27 & 28, which Cash & Hopkinson (Ray Soc. 1908) consider to represent this species; this form possesses spines intermediate in length between those of this species and *C. vestitum*. The aperture varied from being about two-thirds the diameter of the test to a narrow slit, according to the movements of the animal. The pseudopodia, nucleus, etc., are accurately represented by Leidy.

Diameter 32–35 μ; nucleus 6 μ dia. with a well-defined central nucleole; spines about 8–10 μ in length.

Distribution.—Trout Pond, Good Ground, Long Island.

Family Euglyphina.

Euglypha denticulata, *Brown*.

In Scott. Nat. 1912, p. 111, pl. 5. figs. 5–11.

This recently described species bears a close resemblance to a colourless

form of *Assulina muscorum* devoid of the membrane bordering the aperture; the plasma, nucleus, and pseudopodia are also similar; it is widely distributed but not very numerous, and seems always to occur in association with *A. muscorum*.

Length 42–52 μ; breadth 23–30 μ.

Distribution.—West Point, N.Y.; South America; Java; Great Britain.

Euglypha filifera var. pyriformis, var. nov. (Pl. **15**. fig. 6.)

E. ciliata pars, Leidy (**6**), p. 214, pl. 36. fig. 14.

E. filifera, form "*c*," Wailes (**16**), p. 148.

Test usually smaller than the type, pyriform with elongated neck, the lateral margins furnished with 5–7 long spines arranged in a single row; transverse section elliptical; aperture circular bordered by 8 denticulated scales; plasma and pseudopodia as in the type.

Length 48–60 μ; breadth 24–30 μ; aperture 6–10 μ; thickness 17–23 μ; spines 18–26 μ in length.

Distribution.—Good Ground, Long Island; Pennsylvania (*Leidy*).

This variety is referred to as form *c* on p. 148, Journ. Linn. Soc., Zool. vol. xxxii. (1912), but specimens submitted to Dr. Penard were declared by him not to be *E. filifera*, Penard.

The tests of this variety are usually somewhat more compressed than in the type, the thickness varying from two-thirds to three-quarters of the breadth. It is not of common occurrence.

Euglypha strigosa var. muscorum, *Wailes* (**17**), p. 42.

Forma heterospina, f. nov.

This form was recorded with the test thickly covered with spines of various lengths.

Length 65–70 μ; breadth 55–58 μ; aperture 16–17 μ; spines 6–26 μ in length.

Distribution.—Palisades, N.J.

Assulina seminulum var. scandinavica, *Penard* (**8**), p. 519.

A. scandinavica, Penard in Mém. Soc. Genève, xxxi. (1890) no. 2, p. 176, pl. 9. figs. 1–13.

Only one or two individuals were seen and these very small; it is usually found in elevated situations.

Length 77 μ; breadth 73 μ; aperture 24 μ; nucleus 22 μ in diameter, containing nucleoles 6 × 4 μ; scales 10 μ in length.

Distribution.—Palisades, N.J.

Trinema enchelys var. galeata, *Penard in Mém. Soc. Genève*, xxxi. (1890) no. 2, p. 186.

This variety, approaching *T. complanatum* in appearance, is widely distributed and was occasionally seen in an active state.

Distribution.—Van Cortlandt Park, West Point, Long Island, N.Y.; Palisades, N.J.

Family Gromiina.

Pamphagus mutabilis, *Bailey*.

In Amer. Journ. Sci. & Arts, vol. xv. (1853) p. 341.
Leidy (6), p. 191, pl. 33. figs. 1–9.

In a pool on the Palisades this species occurs numerously; many were seen in an active state.

Length 45–60 μ; breadth about half the length.

Distribution.—New Jersey! (6); West Point, N.Y. (*Bailey*); Pennsylvania (6); Wyoming (6); Iowa (*Edmondson*).

Pseudodifflugia fasicularis, *Penard* (8), p. 453.

Unusually scarce, being found in only one gathering, where it occurred in association with *P. gracilis*.

The majority of individuals had smoother tests than is usual and one empty test was perfectly smooth with a sharply defined narrow collar around the aperture.

Length 26–30 μ; diameter 18–20 μ; aperture 10 μ.

Distribution.—Palisades, N.J.

Diaphoropodon mobile, *Archer*.

In Quart. Journ. Micros. Sci. n. s. ix. (1869) p. 394, pl. 20. fig. 6.

In one gathering of sphagnum this species was numerous, but in no instance were the pseudopodia fully displayed. The test is thick but smooth and pliable; its shape is very variable, ovoid, pyriform, or even sometimes constricted in the middle, but it is not usually compressed; the fine cils with which it is thickly covered are colourless, and under a low power appear like a hyaline investment; they are from 8–10 μ in length and become invisible in Canada balsam, oil of cloves, and glycerine; they are insoluble in cold sulphuric acid.

Length 70–113 μ; breadth 50–65 μ; aperture variable; nucleus about 20 μ in diameter.

Distribution.—In sphagnum from Trout Pond, Good Ground, Long Island.

Family Amphistomina.

Diplophrys Archeri, *Barker*.

In Quart. Journ. Micros. Sci. n. s. viii. (1868) p. 123.

On some water-plants a young colony of embryos of this species was seen in an amœboid state; the individuals were 4 μ in diameter, and the colony, about 50 μ in length, displayed numerous pseudopodia about 30–40 μ in length.

Leidy, 1879, Pl. 45. figs. 7, 9, shows such a colony which he doubtfully ascribes to this species, but in reality it belongs to the Heliozoon *Elæorhanis cincta*, Greeff, whose embryos contain reddish globules, whereas the globules in *D. Archeri* are usually yellow but sometimes of a pale blue colour (*v.* Penard, 'Les Héliozoaires,' 1904, p. 228).

Distribution.—Palisades, N.J.

Sub-Class **HELIOZOA.**

Family Actinophryidæ.

Actinosphærium Eichhornii, *Ehrenb.*

Leidy (**6**), p. 259, pl. 46. figs. 1–11.

This species occurs numerously in several localities ; many small ones (Leidy, figs. 3 & 5) were seen, the result of the division of mature individuals.

Distribution.—Palisades ; Englewood ; West Point, N.J.

SOUTH AMERICA.

During the years 1911 and 1912 moss and squeezings were received that had been collected by James Murray in South America, for examination for Rhizopoda ; the gatherings from Bolivia and Peru are described in his 'Notes on the Natural History of Bolivia' (1913) ; the others are here described.

List of gatherings :—

(1) Antofagasta, Chili ; one gathering from a pond : 6 species.

(2) Valparaiso, Chili ; one gathering from a pond : 7 species.

(3) Puntas Arenas, Straits of Magellan, Chili ; gatherings from sphagnum, ponds, and stream : 29 species.

(4) Rio Janeiro, Brazil ; gatherings from moss (shore and inland), ponds, and sphagnum collected on the slopes and near the summits of Mt. Papagaio (4000–5000 ft.) and Mt. Corcovada (2200 ft.) : 55 species.

(5) Buenos Ayres, Argentina ; moss from trees : 3 species.

(6) Panama, Central America ; a sample of dry sandy moss : 8 species.

Little is known of the distribution of the Rhizopoda in South America. Ehrenberg (1841) records *Arcella pileus* and two other species, and in 1871

(Abh. Kgl. Akad. Wiss. Berlin) he records from Venezuela six species of which *Trinema enchelys* (*Arcella caudicola*, pl. 2. f. 31) is the only one that can be identified with certainty; of the remaining five Difflugiæ, four are species of *Nebela* and one is a species of *Euglypha*; from Cape Horn he records three species, viz.: *Difflugia phiala* (f. 9), which resembles *Nebela Murrayi* in outline, but the absence of all detail prevents its identification, *D. hermitana* (f. 10), which has an outline resembling *Nebela Certesi*, and *D. antarctica*, which is some species of *Euglypha*. Certes (3) records 28 species and varieties from Cape Horn including four new species *.

From Paraguay, Daday (4) records 34 species including five interesting and curious new ones. Dr. Fuhrman has submitted a collection of material, made during his recent expedition to the Andes of Colombia, to Dr. Penard for examination, but the report is not yet published.

The collections made by J. Murray provided a total of 74 species and varieties, three of which are now first described, and one (*Arcella megastoma*, Pl. 15. figs. 1 & 2) is described above, p. 204. Nearly all the species recorded are of common occurrence in other parts of the world, but the following may be noted as either rare or seldom recorded previously :—

Awerinzewia cyclostoma.
Bullinula indica.
Corycia aculeata.
„ *flava* var. *coronata.*
Nebela caudata.
„ (*Hyalosphenia*) *cockayni.*
„ *scutellata.*
„ *tropica.*
„ *vas.*

Of these, *Nebela cockayni* has been recorded previously only from Oceania, and *N. vas* from localities bordering the Pacific Ocean (3, 11); several species recorded by Certes and Daday were not found.

The Nebelæ now first described are interesting owing to their affinities and peculiarities; *N. spicata* occurs at Sandia, Peru, but was not found in time to be described in J. Murray's report.

Judging from the materials examined, many places on the coasts of South America, also large tracts of forest, are very deficient as regards the Rhizopod fauna, owing no doubt to unfavourable conditions as to humidity and sunlight; in localities where conditions are more favourable the number of species still appears to be restricted, but individuals are often numerous. Investigations carried on *in situ* are sure to result in adding many species to those recorded.

Notes on some of the less common species that were found are appended.

Trinema constricta, Certes, is *Corythion dubium*, Taránek, and *Trinema sauvineti*, Certes, is a Rotifer test.

	Chili.			Rio Janeiro, Brazil.	Buenos Ayres, Argentina.	Panama.
	Antofagasta.	Valparaiso.	Puntas Arenas.			
	1	2	3	4	5	6
Class SARCODINA.						
Sub-Class **RHIZOPODA.**						
Order AMŒBINA.						
Family Lobosa.						
Amœba terricola, *Greeff*	×	..	×			
Order CONCHULINA.						
Family Arcellida.						
Arcella arenaria, *Greeff*	..	×	×	×	×	
„ discoides, *Ehrenb.*	..	×	×	×		
„ megastoma, *Penard*	..	..	×			
„ vulgaris, *Ehrenb.*	×	..	×			
„ „ *var.* gibbosa (*Pen.*), *West*	..	..	×	×		
Pseudochlamys patella, *Clap. et Lach.*	..	..	..	×		
Corycia aculeata (*Greeff*), *Awer.*	..	..	..	×		
„ flava (*Greeff*), *Pen.*	..	..	..	×		
„ *var.* coronata (*Pen.*)	..	..	..	×		
Bullinula indica, *Pen.*	..	..	..	×		
Centropyxis aculeata (*Ehrenb.*), *Stein*	×	..	×	×		
„ „ *var.* discoides, *Ehrenb.*	..	..	..	×		
„ „ *var.* ecornis (*Ehrenb.*), *Leidy*	..	×	..	×		
„ „ *var.* hemispherica (*Barnard*), *Wailes* (7)	×					
„ arcelloides, *Pen.*	..	..	×	×	×	
Plagiopyxis callida, *Pen.*	..	×	..	×		
„ labiata, *Pen.*	..	..	..	×		
Family Difflugina.						
Difflugia constricta, *Ehrenb.* (*Leidy*)	..	×	..	×	..	×
„ gramen, *Pen.*	..	..	×	×		
„ lucida, *Pen.*	..	..	..	..	×	×
„ oblonga, *Ehrenb.*	..	..	×	×		
„ „ *var.* venusta (*Pen.*), *Cash*	..	..	..	×		
„ tuberculata *var.* minor, *Pen.*	..	..	..	×		
Pontigulasia compressa (*Carter*), *Cash*	..	..	..	×		
Phryganella hemispherica, *Pen.*	..	..	×	×	..	×
„ nidulus, *Pen.*	..	..	..	×	×	
Trigonopyxis arcula (*Leidy*), *Pen.*	..	..	..	×		
Lesquereusia spiralis, *Bütschli*	..	..	..	×		

	1	2	3	4	5	6
Family Nebelina.						
Hyalosphenia papilio, *Leidy*	..	..	..	×		
„ subflava, *Cash*	..	..	×			
Nebela caudata, *Leidy*	..	..	..	×		
„ cockayni (*Pen.*)	..	..	×			
„ collaris, *Leidy*	..	..	×	×		
„ dentistoma, *Pen.*	..	..	×	×		
„ „ *var.* hesperia, *var. nov.*	..	..	×	×		
„ gracilis, *Pen.*	..	..	..	×		
„ lageniformis, *Pen.*	..	..	×	×		
„ militaris, *Pen.*	..	..	..	×		
„ Murrayi, sp. nov.	..	..	×	×		
„ parvula, *Cash*	..	..	..	×		
„ scutellata, *Wailes*	..	..	×	×		
„ spicata, sp. nov. (Peru)						
„ tropica, *Wailes*	..	..	..	×		
„ tincta (*Leidy*), *Awer.*	..	..	..	×		
„ vas, *Certes*	..	..	×	×		
„ vitræa, *Pen.*	..	..	..	×		
Quadrula symmetrica, *F. E. Schulze*	..	..	..	×		
Heleopera sordida, *Pen.*	..	..	..	×		
„ sylvatica, *Pen.*	..	..	..	×		
Awerinzewia cyclostoma (*Pen.*), *Schout.*	..	..	..	×		
Cochliopodium bilimbosum (*Auerb.*), *Leidy*	..	..	×			
Family Euglyphina.						
Euglypha armata, *Wailes*	..	..	..	×		
„ alveolata, *Duj.*	×	..	×	×	..	×
„ ciliata, *Ehrenb.*	..	×	..	×		
„ cristata, *Leidy*	..	..	×			
„ compressa, *Carter*	..	×	..	×		
„ denticulata, *Brown*	×	..	×	×		
„ filifera, *Pen.*	..	..	×			
„ lævis, *Perty*	..	..	×	×	..	×
„ strigosa (*Ehrenb.*), *Leidy*	..	..	×	×	..	×
„ „ f. glabra	..	..	×	×		
„ „ f. heterospina	..	..	..	×		
„ „ *var.* muscorum, *Wailes*	..	..	..	×	..	×
Assulina muscorum, *Greeff*	..	..	×	×		
Cyphoderia ampulla (*Ehrenb.*), *Leidy*	..	..	×			
Trinema enchelys (*Ehrenb.*), *Leidy*	..	..	×	..	..	×
„ „ *var.* galeata, *Pen.*	..	..	..	×		
„ complanatum, *Pen.*	..	..	..	×		
„ lineare, *Pen.*	..	..	×	×		
Corythion dubium, *Taránek*	..	..	×	×		
Sphenoderia fissirostris, *Pen.*	..	..	×			
Family Gromiina.						
Pamphagus mutabilis, *Bailey*	..	..	×			
Pseudodifflugia fascicularis, *Pen.*	..	..	..	×		
„ gracilis, *Schlumb.*	..	..	×			

Order AMŒBINA.

Amœba terricola, *Greeff, in Arch. f. mikr. Anat.* i. (1866) p. 300, pl. 17. figs. 1–11.

A. verrucosa, Ehrenb. Infus. 1838, p. 126, pl. 8. fig. 11.
A. papyracea, Penard (**10**), Bd. 6, 1905, p. 201.

Owing to the possession of a comparatively firm pellicle this species is able to withstand desiccation for quite lengthy periods, and often to be identified in preserved gatherings. A study of this species and its allies by Penard has recently appeared (Archiv f. Protist. 1912).

Order CONCHULINA.

Bullinula indica, *Penard* (**11**), p. 225, pl. 22. fig. 1.

Bulinella indica, Penard (**12**), p. 274, pl. 14. figs. 1–4.

Occurs in sphagnum on Mt. Papagaio, Rio Janeiro.

Length about 200 μ ; breadth about 180 μ.

Distribution.—Peru (**7**) ; United States (**16**) ; Canada (**11**) ; Europe (**17**, **9**, 1912) ; Australasia (**11**) ; India (**12**) ; Seychelles (**16**).

Corycia aculeata (*Greeff*), *Awerinzew* (**1**), p. 142.

Pseudochlamys aculeata, Greeff (**5**), p. 104.
Corycia coronata, Penard (**8**), p. 178.

This rare species occurs in moss on the shore near Rio Janeiro ; the spines, usually numerous (8–12), are well developed but never long. The tests were of medium size.

Diameter 90–100 μ.

Corycia flava (*Greeff*), *Penard* (**8**), p. 173.

Amphizonella flava, Greeff, in Arch. f. mikr. Anat. ii. (1866) p. 329, pl. 18. fig. 19.

In addition to tests of typical size, 80–100 μ in diameter, several large tests were seen, similar to those which occur in Bolivia (**7**) measuring from 120–165 μ in diameter ; some of these were circular, others folded up ; they may perhaps be *Parmulina brucei*, Penard (**13**), but the facets present on the tests of that species were never distinguishable ; it is to be hoped that specimens will be found in the materials collected by the Fuhrman expedition that will enable Penard to complete his description of that species and render its identification more certain.

C. flava var. coronata (*Penard*).

Corycia coronata var. *simplex*, Penard (**8**), p. 179.
Corycia penardi, Awerinzew (**1**), p. 143; Schouteden (**15**), p. 332.

A few tests that belonged to this variety were found in moss ; the projecting ring around the crown of the test is often only rudimentary and

the animal is scarcely distinguishable from *C. flava* ; for this reason Dr. Penard is now of opinion (private letter) that it should be regarded as a variety of that species.

Diameter 93–100 μ.

Distribution.—Rio Janeiro, Brazil.

Nebela caudata, *Leidy* (6), p. 160, pl. 26. figs. 21–24. (Pl. 15. fig. 17.)

Although never numerous this species is widely distributed throughout the world. In order that a comparison can be made with *N. spicata*, sp. nov., a drawing is given of an individual from near the summit of Corcovada Mt.

Length, without spines, 80–90 μ ; breadth 65–75 μ ; aperture 20–25 μ ; spines 3 or 4 in number.

Distribution.—Brazil, Bolivia, and Peru (7) ; Gough Island (13) ; United States (6, 16) ; Canada (11).

Nebela cockayni (*Penard*).

Hyalosphenia cockayni, Penard (11), p. 238, pl. 22. fig. 5.

The individuals found by Penard in Oceania possessed transparent tests with very faint indications of the plates or scales ; those at Puntas Arenas are distinctly marked, having typical *Nebela*-like tests composed of small oval plates closely cemented together ; they are considerably larger than any previously recorded, also less compressed, the thickness being about 0·6 of the breadth ; the aperture in one case was 28×10 μ, in another 25×14 μ, being narrowly elliptical. There are, as shown by Penard, two small pores in the sides of the neck and no other openings in the body of the test. Only empty tests were found.

Length 120–126 μ ; breadth 74–75 μ ; aperture 25–28 μ ; thickness 42 μ.

Distribution.—Puntas Arenas ; Australasia (11) ; Auckland Islands (l. 89–100 μ) ; Sydney (l. 100 μ); Mt. Cook, New Zealand (l. 115 μ).

Nebela dentistoma var. hesperia, var. nov. (Pl. 15. fig. 13.)

In addition to a few individuals of the typical *N. dentistoma*, Penard, a form with a much larger test was found numerously in some gatherings, which is here recorded, at least for the present, as a variety of that species ; a future examination of living individuals may perhaps result in it being regarded as an autonomous species. The following is a description of the tests, no information as to the plasma, etc., being available.

Test large, pyriform, compressed, composed of oval, round, or square plates in varying proportions with an occasional admixture of diatom frustules and *Euglypha* scales; transverse section elliptical ; aperture elliptical, its border not thickened, slightly undulate and usually formed of oval scales; in narrow side-view, the fundus rounded, and the sides tapering in convex lines to the aperture.

Length 155–190 μ; breadth 100–142 μ; aperture 32–50 μ; thickness 0·5 to 0·6 of the breadth.

The proportions of the test vary considerably, the breadth ranging from 0·6 to 0·8 of the length, the narrow tests having an ovoid outline. The average of 13 tests gave: length 175 μ, breadth 128 μ, aperture 38 μ; two tests each 170 μ in length measured 100 μ and 140 μ in breadth respectively.

This variety is distinguished from *N. dentistoma* var. *lacustris*, Wailes (**16**), by the absence of any definite neck and by the structure of the test, which consists of small plates with regular outlines.

Distribution.—Puntas Arenas; Mt. Corcovada, Rio Janeiro (sphagnum).

Nebela Murrayi, sp. nov. (Pl. **15**. figs. 18, 19.)

Test of medium size, broadly pyriform, compressed, nearly colourless, usually formed of oval or circular plates; in broad view nearly circular, with a short, wide, parallel neck; furnished with two orifices on each side situated in depressions at the base of the neck, each pair of orifices contracted by an internal tube; the neck bearing a variable number of small circular granules; the test in narrow side-view having a slightly protuberant apex, widening to the centre of the body thence tapering gradually to the neck; transverse section elliptical; aperture elliptical with thickened lip; plasma grey, granular, containing numerous food-particles; nucleus moderately large with several nucleoles; pseudopodia not observed.

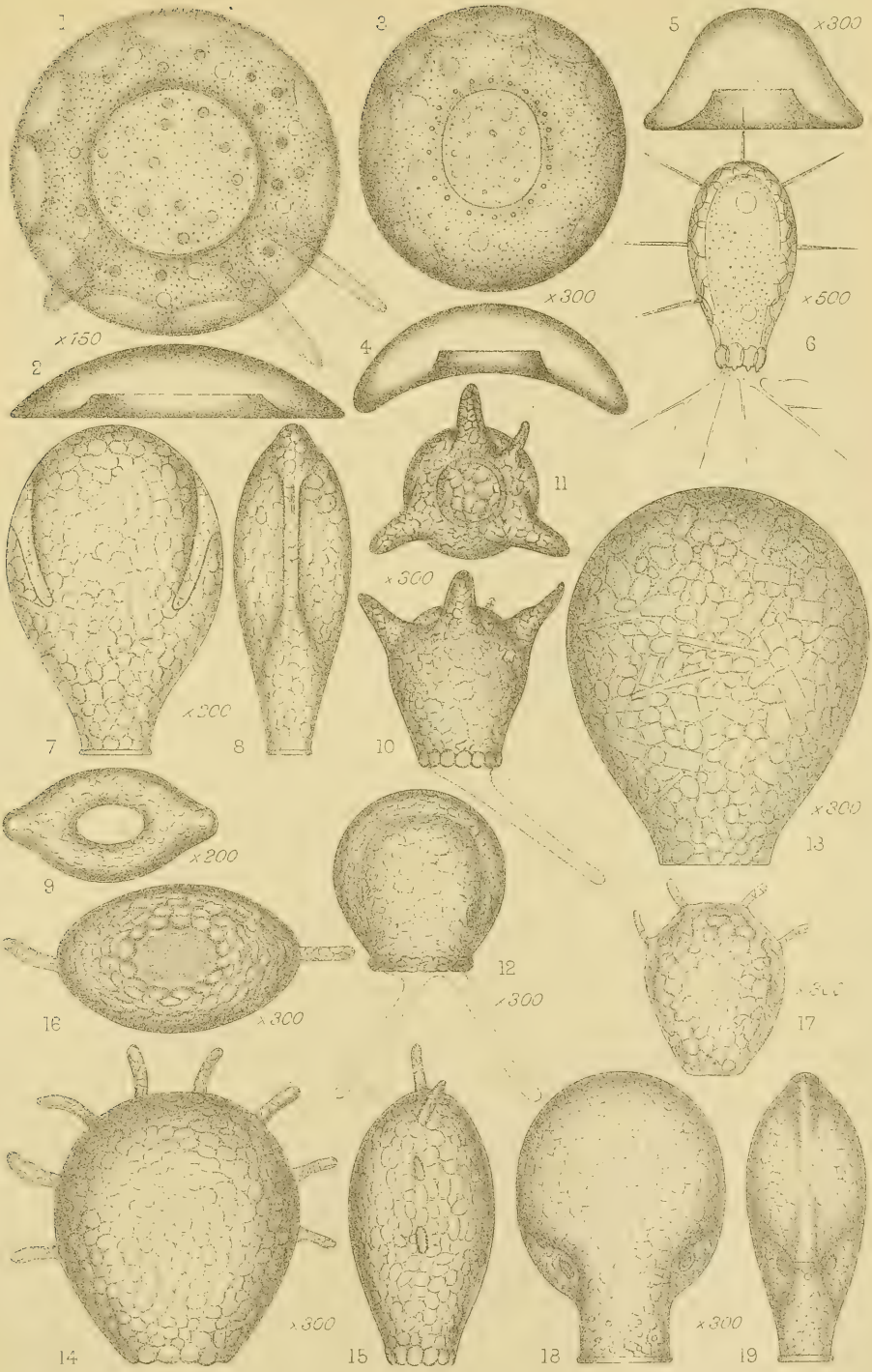
Length 120–136 μ; breadth 95–100 μ; aperture 30–35 μ; thickness about half the breadth.

Distribution.—Puntas Arenas; Mt. Papagaio, Rio Janeiro.

This species belongs to a group of Nebelæ in which the curious lateral pores are characteristic; the other members are *N. bigibbosa*, Penard, *N. martiali*, Certes, *N. Certesi* (Certes), Penard, but none of these were found in the gatherings under examination. So far as is known at present *N. bigibbosa* is peculiar to the Northern Hemisphere, and *N. Certesi* to the Southern; the latter and *N. martiali* are also distinguished by the presence of the small nodules on the neck. *N. Certesi* has in addition tubular channels running up the neck from the aperture, and the lateral internal tubes are sometimes only rudimentary.

Nebela spicata, sp. nov. (Pl. **15**. figs. 14, 15, 16.)

Test of medium size, of a grey colour, ovoid, moderately compressed, formed of various-sized oval or irregularly shaped scales; the crown circular, furnished with a single row of 6–8 hollow spines; test in narrow side-view pyriform; transverse section elliptical, ratio of axes about 5 : 3; aperture broadly elliptical with undulate margin bordered by a row of oval scales; plasma normal; pseudopodia not observed.



G.H.Wailes del. West, Newman lith.

RHIZOPODA FROM NORTH & SOUTH AMERICA.

Length (without horns) 120–140 μ ; breadth 100–125 μ ; aperture 32–40 μ ; thickness 0·5 to 0·6 of the breadth ; length of horns 20–30 μ.

Habitat. Sphagnum.

Distribution.—Sandia, Peru.

In the small quantity of material available some ten individuals were found, but owing to the fragile nature of the horns many of these were imperfect. The test is opaque, strongly constructed, and of a robust form, the outlines follow regular curves, being free from excrescences ; the crenulations around the aperture are often pronounced, resembling those of *Nebela dentistoma*, a species to which it bears a close likeness when deprived of the spines. It is distinguished from *Nebela caudata* (fig. 17), a species found in association with it, by its much larger size and robust form, its more regular outlines and greater number of spines. Encysted individuals contained plasma of normal appearance.

Nebela scutellata, *Wailes* (**16**), p. 139, pl. 12. figs. 11, 12.

Not uncommon and quite typical.

Distribution.—Puntas Arenas (sphagnum) ; Mt. Corcovada (sphagnum) and Rio Janeiro (shore moss) ; United States (**16**) ; Seychelles (**16**).

Nebela tropica, *Wailes* (**16**), p. 140, pl. 12. figs. 13, 14.

Found in association with the preceding.

Distribution.—Puntas Arenas ; Rio Janeiro ; Peru (**7**) ; Borneo (**16**) ; Seychelles (**16**).

Nebela vas, *Certes* (**3**), p. 15, pl. 1. figs. 4 & 5.

Not uncommon in some of the gatherings of sphagnum, and of moderate size. A certain amount of variation was observable in the neck, the base varying considerably not only in width but in the depth of the depression or groove at the point where the neck is attached to the body of the test; some individuals in broad view closely approached *N. lageniformis* in appearance, but in side view the difference was pronounced.

Length 130–155 μ; breadth 85–103 μ; aperture 26–32 μ.

Distribution.—Puntas Arenas ; Rio Janeiro ; Cape Horn (length 140–170 μ, *Certes*) ; Antarctic, Australasia, Fiji, Hawaii, and British Columbia (*Penard*).

Penard found the usual size to be 160–165 μ in length, but in New ealand a small form occurs 95 μ in length (**11**).

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EXPLANATION OF PLATE 15.

Figs. 1, 2. Arcella megastoma, sp. nov., Penard. Dorsal and side views, × 150. New Jersey.

3, 4. Arcella curvata, sp. nov. Dorsal and side views, × 300. Norfolk, Virginia.

5. Arcella vulgaris, forma. Side view, × 300. Norfolk, Virginia.

6. Euglypha filifera var. pyriformis, var. nov. Side view of active individual, × 500. Long Island, U.S.A.

7–9. Nebela saccifera, sp. nov. Broad, narrow, and oral views of test, × 200. Long Island, U.S.A.

10, 11. Difflugia bicornis, Penard. Three-horned form; side and dorsal views, × 300. New Jersey.

12. Difflugia olliformis, Lagerheim. Side view of active individual, × 300. New Jersey.

13. Nebela dentistoma var. hesperia, var. nov. Broad view of test, × 300. Rio Janeiro, Brazil.

14–16. Nebela spicata, sp. nov. Broad, narrow, and oral views, × 300. Sandia, Peru.

17. Nebela caudata, Leidy. Broad view, × 300. Sandia, Peru.

18, 19. Nebela Murrayi, sp. nov. Broad and narrow views, × 300. Puntas Arenas, Chili.

On *Aphareocaris*, nom. nov. (*Aphareus*, Paulson), a Genus of the Crustacean Family Sergestidæ.

By W. T. Calman, D.Sc., F.L.S.*

(Plate 16.)

[Read 19th June, 1913.]

The genus *Aphareus* was established by Paulson in 1875, for a species which he described from a single specimen taken in the Red Sea. He placed it in the family Penæidæ, but did not further discuss its affinities. No further specimens appear to have been recorded, and, so far as I am aware, the genus has only been mentioned twice by later writers. Mr. Stebbing, in 1893, gave a definition of the genus, derived from Paulson's account, but transferred it to the tribe Stenopidea; Nobili, in 1906, gave a translation † of Paulson's description, reproduced some of his figures, and suggested that the proper place of the genus was in the family Sergestidæ.

Among a small collection of Crustacea from Thursday Island, Torres Straits, recently presented to the British Museum by Dr. J. R. Tosh, is a specimen of what I regard as a second species of the genus. It is a male, adult or nearly so, and was quite perfect; in view of the divergent opinions expressed as to the affinities of the genus, it seems worth while to give a somewhat detailed account of it.

Unfortunately, the name *Aphareus* is preoccupied for a genus of fishes, and it is therefore necessary to propose a new name for the Crustacean genus.

Genus Aphareocaris, nom. nov.

Aphareus, Paulson, Izslyedovaniya Rakoobraznuikh Krasnagho Morya. Chast I. Kiev, 1875, p. 117; Stebbing, History of Crustacea (Internat. Sci. Ser.), 1893, p. 212; Nobili, Ann. Sci. Nat. ser. 9, Zool. iv. 1906, p. 21; nec *Aphareus*, Cuvier et Valenciennes, Hist. Nat. Poissons, vi. 1830, p. 485.

Genotype.—*Aphareus inermis*, Paulson, op. cit. p. 117, pl. xviii. figs. 3–3*a*.

Aphareocaris elegans, sp. nov.

Description of male.—Total length 20 mm. (Pl. 16. figs. 1–16.)

Body slender and compressed. *Carapace* just over one-fourth of total length, with a very short acute *rostrum* continued backwards as a short dorsal crest cut into two teeth; with a supra-orbital and a hepatic spine, the

* Published by permission of the Trustees of the British Museum.

† I am much indebted to Dr. K. Andersen for a fresh translation of the passages in Paulson's Russian memoir. The additions to Nobili's version are, however, unimportant, and no light is thrown on the obscurities to which he calls attention.

latter placed at about one-fourth of the length of the carapace from the front margin; the antero-lateral margin sloping backwards from the base of the antennules to a very minute pterygostomial tooth; inter-regional grooves on surface of carapace very indistinct.

Anterior *abdominal somites* rounded dorsally, fifth and sixth obscurely carinate; pleural plates of first somite bilobed; sixth somite twice as long as fifth, measured along dorsal edge. *Telson* (Pl. 16. fig. 3) four-fifths of length of sixth somite, acutely pointed, with a longitudinal median dorsal groove, and with five pairs of small marginal spinules.

Ocular peduncle (fig. 2) about one-third of length of carapace, not reaching end of first segment of antennular peduncle, widening distally; corneal area occupying less than one-fourth of length of second segment, little wider than adjacent part of peduncle, dark brown with lighter periphery.

Antennular peduncle (fig. 2) about four-fifths of length of carapace, the first segment, measured along outer edge, about three times as long as second and four times as long as third; tooth of outer margin (stylocerite) rather behind the middle of its length, and a second tooth, or vertically compressed lobe, rising from the upper surface just in front of the statocyst and behind the stylocerite; second and third segments successively narrower. Inner flagellum shorter than peduncle; outer flagellum about $3\frac{1}{2}$ times as long as peduncle, thickened at base, where it carries a brush of sensory filaments; no trace of clasping organ.

Flagellum of *antenna* (fig. 1) more than twice as long as the body, with an abrupt double bend at about three-sevenths of its length from the base; marginal setæ longer and more conspicuous distal to this bend. Antennal *scale* about two-thirds as long as carapace and three times as long as wide; outer margin nearly straight, its terminal tooth considerably surpassed by the rounded distal margin.

Mandibular palp (fig. 4) composed of three segments *, the first very small, the second large and flattened, trapezoidal in outline, about three times as long, and, at its greatest width, three times as broad as the third segment.

Maxillula (fig. 5) resembling that of *Sergestes*.

Maxilla (fig. 6) remarkable for the reduction of the endites; only two are present and these are very small, with one or two minute apical setæ on each.

* It is sometimes given as a general character of the tribe Penæidea that the mandibular palp is composed of only two segments (Spence Bate, Rep. 'Challenger' Macrura, pp. xxxiv & 226, 1888; Bouvier, Res. Camp. Sci. Monaco, xxxiii. Crust. Décap. (Pénéidés) p. 9, 1908). Krøyer, however, attributes three segments to the palp of *Sergestes* (Kgl. Danske Vid. Selsk. Skr. (5) iv. p. 225, 1856), while Boas describes it as three-segmented in *Sicyonia* and *Sergestes*, and as having the first segment obscurely or not at all defined from the second in *Penæus* (Kgl. Danske Vid. Selsk. Skr. (6) i. pp. 31, 34, 36, 1880). I find the small proximal segment quite distinct in *Sergestes robustus*, *Acetes indicus*, *Benthesicymus investigatoris*, and *Sicyonia carinata*, as in the species here described; on the other hand, only two segments can be detected in the palp of several large species of *Penæus*.

First maxilliped (Pl. 16. fig. 7) resembling that of *Sergestes*, especially in the large size of the distal endite, which, however, does not extend so far as the tip of the exopod ; the endopod is composed of four distinct segments.

Second maxilliped (fig. 8) distinctly of the Sergestid type, in the absence of exopod and the lengthening of the distal segments.

Third maxilliped (fig. 9) also of Sergestid type in its great size—it is longer by about two-thirds than the carapace, and extends well beyond the antennular peduncle—the absence of exopod, and the subdivision of the two distal segments, the terminal into four and the penultimate into three segments; it is strongly spinose.

First three pairs of *legs* (figs. 10–12) increasing successively in length and slenderness, all with well-developed chelæ. On the under side of the propodus of the first pair is a group of pectinate spines opposed to a similar group on the carpus*; a trace of a similar arrangement is observable in the second pair. Propodus of third pair at least ten times as long as wide and nearly three-fourths as long as carpus.

Last two pairs of legs (figs. 13 & 14) each with the normal number of seven segments, the dactylus being short and slightly curved ; the other segments are flattened, the ischium and merus fringed with very long setæ on both margins, the carpus and propodus only on the inner margin.

The *pleopods* of the first pair carry a petasma (figs. 15 & 16), the middle lobe of which has the terminal area beset with numerous invaginated hooks like those figured by S. I. Smith in *Sergestes robustus*. The remaining pleopods are biramous ; those of the second pair have a spinose appendix masculina.

The *uropods* have the exopod longer than the endopod, which, again, longer than the telson ; the marginal tooth of the exopod is about one-sixth of the total length from the tip.

The branchial system is much reduced. Unfortunately, the method of preservation (formalin followed by spirit) has left the branchiæ very transparent and difficult to see. It is possible, therefore, that one or two of the vestigial branchiæ may have been overlooked, but, with this reservation, the formula may be given as follows :—

	mxp. 1.	mxp. 2.	mxp. 3.	pe_r. 1.	per. 2.	per. 3.	per. 4.	per. 5.
Pleurobranchiæ.....	—	?	1+r	1+r	1+r	1+r	2	—
Arthrobranchiæ.....	—	—	—	—	—	—	—	—
Podobranchiæ	ep.	1+ep.	—	—	—	—	—	—

* Coutière has called attention to a similar apparatus in various Caridea and Penæidæ (C. R. Acad. Sci. Paris, cxli. p. 220, 1905). It has not been observed in Sergestidæ.

This is practically the formula given by S. I. Smith for *Sergestes japonicus*, Sp. Bate (*S. mollis*, Smith), but the branchiæ, and especially those of the penultimate somite, are much larger than in that species and, of the vestigial branchiæ, the posterior two at any rate show a certain amount of lobulation.

Affinities.—The genus *Aphareocaris* resembles *Sergestes* in the following, among other less important characters :—

(1) The reduction of the branchial system, and the insertion on the body-wall of those branchiæ which correspond to the arthrobranchiæ of the Penæidæ.

(2) The absence of exopodites from all the thoracic limbs except the first maxillipeds.

(3) The form of the second and third maxillipeds and particularly the subdivision of the two distal segments of the latter.

(4) The flattened form and long marginal setæ of the last two pairs of legs.

It differs from *Sergestes* and the other Sergestidæ, and resembles the Penæidæ, in the following points :—

(1) The first three pairs of legs are chelate and none of their segments are subdivided.

(2) The last two pairs of legs possess the full number of seven segments.

(3) The antennule of the male is without a prehensile apparatus.

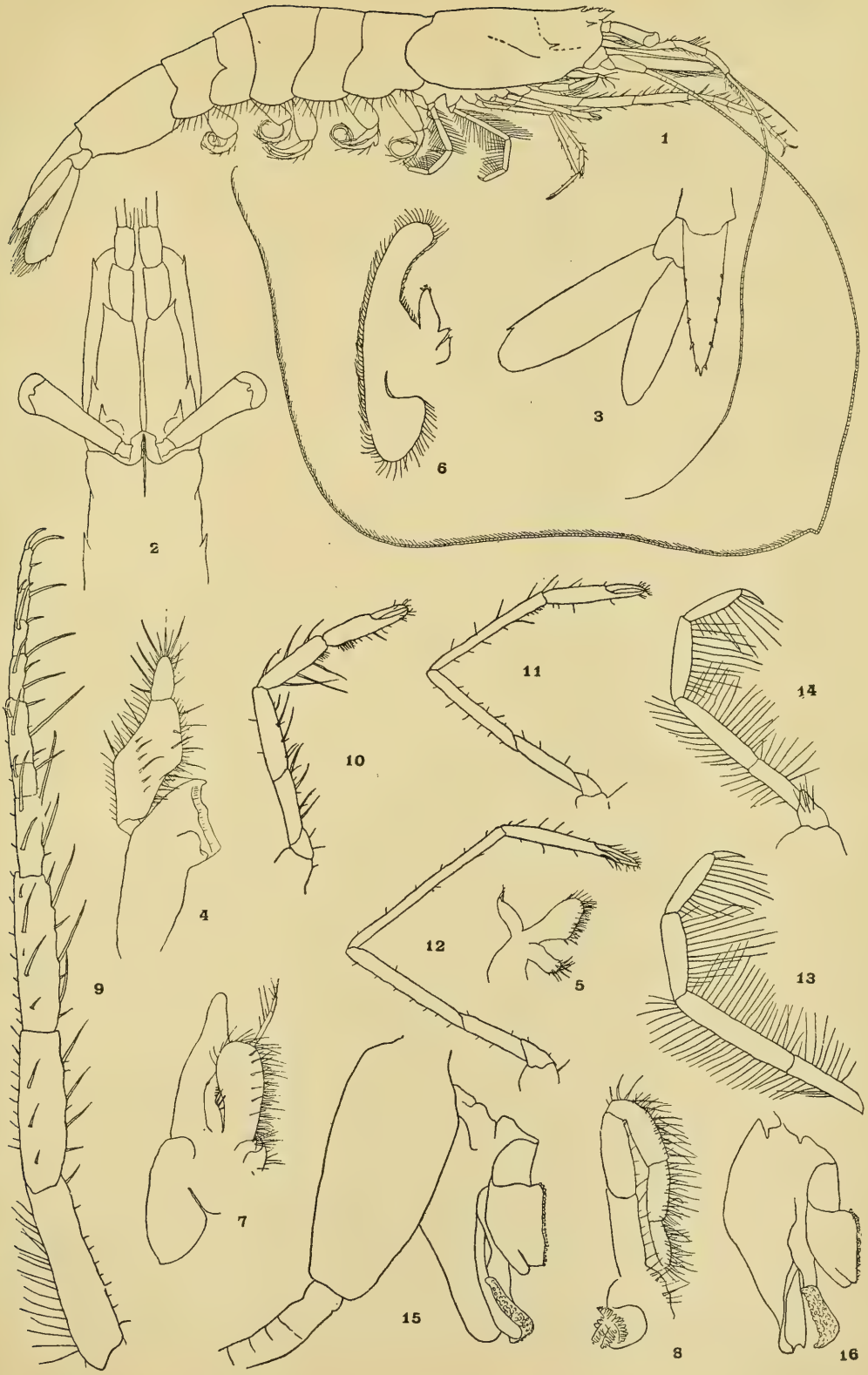
These resemblances to the Penæidæ are all of a general character, serving to indicate the primitive position of *Aphareocaris* with respect to the more specialized genera of Sergestidæ, but not in any way counterbalancing the important and positive characters by which it is linked to that family. It seems, therefore, that Nobili was justified in his suggestion that the genus should be placed among the Sergestidæ. Of an affinity with the Stenopidea, as suggested by Mr. Stebbing, I can find no evidence.

Specific characters.—Paulson's specimen may be presumed to have been a female, since he makes no mention of a petasma. It is, therefore, a matter of analogy and conjecture whether the differences from the specimen now described are individual, sexual, or specific. There seems a reasonable probability, however, that some at least of the following belong to the last category.

Rostral crest with one tooth. Penultimate segment of third maxilliped divided into four parts. Chela of third leg not more slender than that of second, about six times as long as wide, and less than two-thirds as long as carpus . *A. inermis* (Paulson), Red Sea.

Rostral crest with two teeth. Penultimate segment of third maxilliped divided into three parts. Chela of third leg much more slender than that of second, at least ten times as long as wide, and nearly three-fourths as long as carpus.

A. elegans, sp. n., Torres Straits.



W. C. del.

APHAREOCARIS.

EXPLANATION OF PLATE 16.

Fig. 1. *Aphareocaris elegans*, sp. n. Male (holotype) from side. × 5.
2. ,, ,, Anterior part of body from above. × 10.
3. ,, ,, Telson and uropod. × 10.
4. ,, ,, Right mandible. × 14.
5. ,, ,, Maxillula. × 14.
6. ,, ,, Maxilla. × 14.
7. ,, ,, First maxilliped. × 14.
8. ,, ,, Second maxilliped. × 15.
9. ,, ,, Third maxilliped. × 15.
10. ,, ,, First leg. × 15.
11. ,, ,, Second leg. × 15.
12. ,, ,, Third leg. × 15.
13. ,, ,, Fourth leg. × 15.
14. ,, ,, Fifth leg. × 15.
15. ,, ,, Peduncle of first pleopod with petasma. × 20.
16. ,, ,, Petasma with the lobes drawn apart. × 20.

A Free-swimming Nauplioid Stage in *Palinurus*.

By J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S. (With 1 Text-figure.)

[Read 3rd April, 1913.]

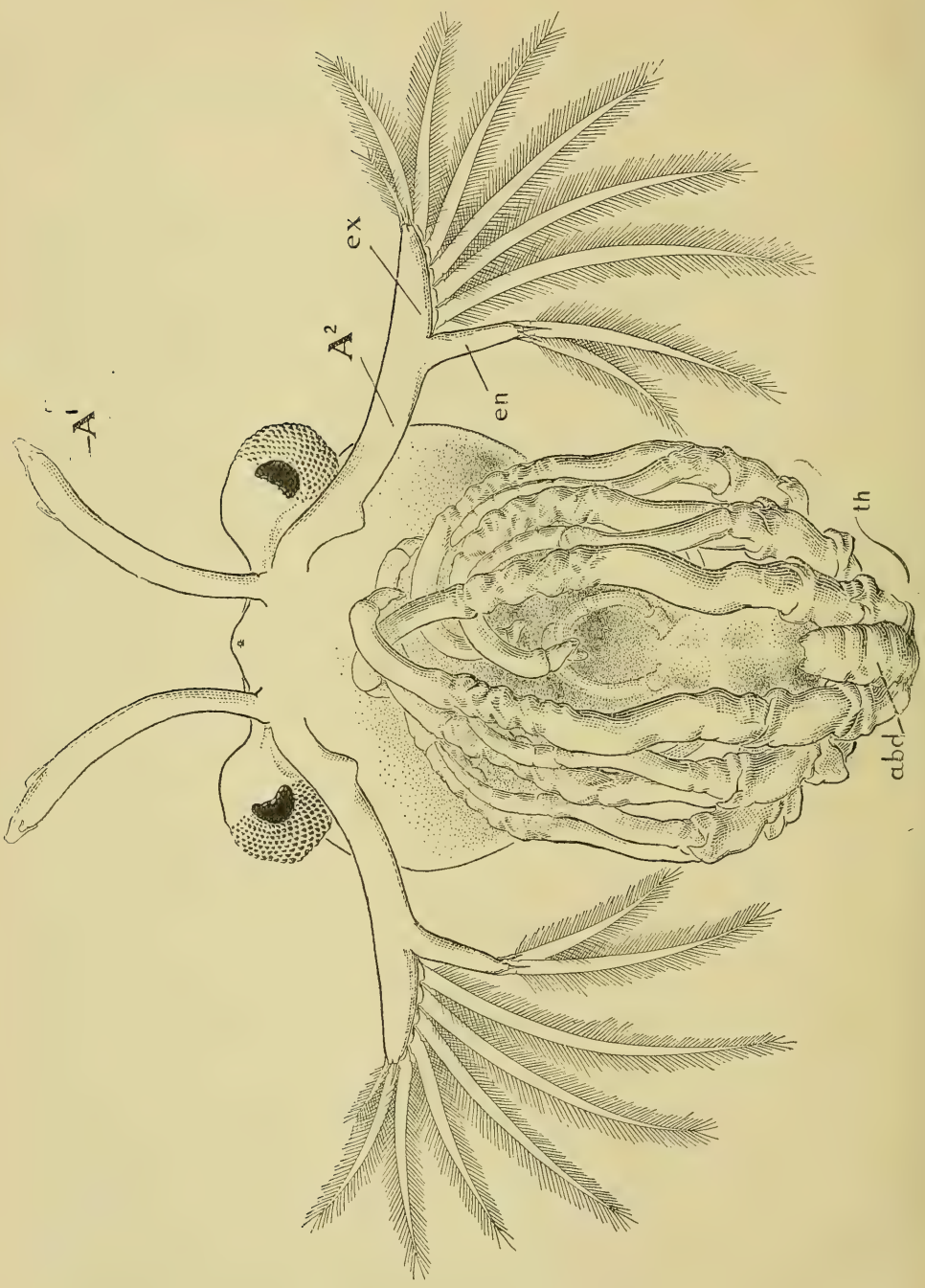
The larva of *Palinurus*, *Scyllarus*, and the Loricata generally has hitherto been supposed to hatch out from the egg in the form of a "phyllosoma," characterised by a flattened transparent body and the presence of swimming-organs, in the form of the exopodites of some of the thoracic appendages.

A number of observations, which I have made on the early stages of *Palinurus* (*Jasus*) *lalandii*, seems to indicate that this is not so in the case of this South African Crawfish.

The observations were made on a number of specimens of this crustacean kept alive in tanks at the Marine Laboratory at St. James, near Cape Town. They are hardy animals, and can be kept in good condition for a considerable length of time without much trouble. On hatching, the larvæ are given off in large numbers, and are readily seen by the naked eye in the typical phyllosoma stage. Among these slowly-moving larvæ was observed a number of nauplius-like forms, with large biramose antennæ, by means of which they rose to the surface in a series of rapid dancing movements. These larvæ on closer examination proved to be, not nauplii, but the earliest free stage, differing considerably from a phyllosoma. The duration of this stage is very brief (4–6 hours), and is readily overlooked, especially if hatching takes place during the night.

In the advanced egg, which measures about 0·7 mm. in breadth and slightly more in length, the embryo is seen to have the body so bent on itself that the thoracic appendages are compactly folded up over the ventral aspect of the body, passing between the eyes, and extend to some considerable distance over the back of the cephalic region. The antennæ are well developed, are longer than the antennules, and biramose; they are folded over the back of the embryo, and their long feathery swimming-setæ overlap each other in this region.

On hatching, the embryo leaves the egg, and, at the same time, throws off the old cuticle, which may sometimes be seen lying alongside of or near the ruptured egg. The antennæ and antennules immediately expand, while the other appendages still retain their folded position. Thus the larva at this stage appears to have a rounded or ovoid body, consisting of cephalic and thoracic regions bent over on each other, the short abdomen and long appendages being folded up ventrally. A little later in this stage, the appendages become somewhat unfolded, and the angle of flexure between the



"Naupliosoma" larva of *Paliurus* (*Jasus*) *latreillii*, ventral aspect, highly magnified.
A¹, antennules. A², antennæ. *ex*., exopodite, *en*., endopodite of the antenna. *th*., thoracic limbs. *abd*., abdomen.

cephalic and thoracic regions becomes less acute, so as to give the whole body a more elongate appearance. This unfolding also occurs in specimens placed in preserving-fluid at this stage.

The superficial resemblance to a nauplius at this stage is striking, especially in the large biramose swimming-antennæ and apparently ovate body, but a closer examination of the body and appendages indicates that the larva is much more advanced in organization than a nauplius, this latter stage having presumably been passed through much earlier in the development of the egg. For convenience the larva may be called a naupliosoma or described as being in a naupliosoma stage.

The *cephalic region* is broad (0·72 mm.), and is almost circular in outline, the length, from the anterior to the posterior margin of the cephalic shield, being about equal to its breadth. This region is not flat and transparent, as in the succeeding phyllosoma stages, its depth (from the centre of the back to the mouth-appendages) being about four-fifths of its breadth, nor is it transparent, being as yet filled with a considerable amount of yellow yolk-granules. The antennal glands, which appear distinctly in the next stage, were seen in some, and also three large hepatic diverticula on each side. Two powerful muscles, which degenerate at a later stage, were observed attached to the base of each of the antennæ. The cephalic shield is rounded dorsally, and extends backwards over the thoracic region to about the anterior margin of the base of the second maxillipeds (in some cases only to the first maxilliped).

The *thoracic region* is bent forward and under the cephalic region, there being, especially at first, a somewhat abrupt flexure of the body at the junction between the two. This region is characterised also by the presence of a well-marked segment—that to which the first maxilliped belongs—which appendage, it is to be noted, is a mere rudiment. The thoracic region is narrow, resembling the body of a pycnogonid, and, except the part mentioned, shows no distinct traces of segmentation. It is transparent except for the presence of a thin yellow streak—the remains of the yolk in the intestine.

The *abdominal region* or tail is short, and, like the thoracic region, is flexed ventrally. In its anterior two-thirds four distinct segments can be distinguished. It is also narrow, scarcely exceeding the breadth of the first joint of the last appendage (the sixth thoracic). It ends in a pair of furcal processes, provided with setæ, which are not yet free, but covered over by cuticle.

The *pigmentation* of the body is striking; the cephalic region and the intestine are of a faint yellow colour from the presence of the yolk, while on the body and limbs are bright blood-red patches of pigment, usually of a stellate structure in the living animal. These are disposed as follows:

at the tips of the antennules (sometimes absent), at the inner side of their bases, on the lower lips (well marked), at the bases of the third maxilliped, the first, second, and third walking-legs, and at the joints and tips of the walking-legs with the exception of their exopodites which are unpigmented.

The paired *eyes* are well developed, and are situated near the anterior margin of the cephalic shield, to which they are attached by short stout stalks. There is a median eye-spot.

The *antennules* project forward between the eyes. They show no traces of segmentation, and the spines, which appear in the next stage, are still covered by cuticle, though a few short terminal ones and a minute one at a little distance from the free extremity can be made out. The bases of the antennules are visible from the ventral side, and are situated slightly posterior to the bases of the eye-stalks. In length the antennules are about three-fourths of the length of the antennæ.

The *antennæ* are the most conspicuous organs, and are in length about four-fifths of the breadth of the cephalic region. Each consists of a rather long and stout protopodite, the main axis of which is continued into a shorter, but also stout, exopodite, while the smaller endopodite appears as a branch to this main stem, though a little later on (at the third moult) it already exceeds the exopodite in length, and, ultimately, alone survives as the main portion of the antenna. Near the base of the protopodite is a papilla-like projection, apparently a masticatory process. From the posterior border of the exopodite arises a series of long cuticular projections, each resting on a ledge-like indentation of the exopodite. They form broad flat swimming-blades, nearly touching each other at their origin, and bent dorsally at their tips. They are provided with a single series of fine setæ on each side. There are five of them arising from the posterior margin of the exopodite and two from its extremity. In length the inner is a little over three times the length of the exopodite, the terminal one being very much smaller. Into this last and the one next it project two spines which become free at the next stage. The endopodite is also provided with long flat cuticular processes, similar to those of the exopodite, but only two in number. The first, or inner, is shorter than the second. They arise from a common base, and into each projects a spine from the tip of the endopodite.

The *upper lip* is well developed and shows active movement in the living state.

The *mandibles* are short stout organs, with a broad base, and terminate in a short thick spine with about three denticulations. No trace of segmentation nor a biramose condition was seen. Their inner extremities are overlapped by the upper lip.

The *lower lip* consists of two well-marked leaf-like lobes, which also overlap the tips of the mandibles from below, and even the margin of the upper lip to a slight extent.

The *first maxilla* is well developed and shows active movement. It is unsegmented, but biramose, each of the short stout branches being turned inwards and terminated by two or three long sharp spines as yet covered by cuticle and apparently not functional.

The *second maxillæ* lie at some distance from the first maxillæ and other mouth-parts. They are comparatively well developed, but unsegmented, being long blade-like organs projecting forward from their points of attachment on the body. Their outer margins are straight, while their inner is convex, and shows no lobes, though provided with a spine. Their greatest breadth is about one-third of their length. At the free extremity of this appendage are three long spines, not easily made out as they are still covered by cuticle.

The *first maxilliped* appears as a minute knob or projection of the body, about one-quarter of the breadth of the first joint of the succeeding appendage in breadth, and not much over this in length. It is terminated by a sharp spine about its own length. It is situated about midway between the neighbouring appendages and towards the middle line of the body, so that its free end scarcely reaches the margin of the body. It is thus a mere rudiment.

The *second maxilliped* is much longer, and extends forward in a curve to about the middle of the cephalic region. It consists of five distinct segments terminated by spines still in cuticle. It is not provided with an exopodite.

The *third maxilliped* is similar to the second, but is longer. Both are, at this stage, folded inwards under the three succeeding walking-legs. There is no exopodite.

The *first and second walking-legs* are much stouter, being about twice the breadth of the preceding appendage at their bases. They are much shorter than in the next stage, being compressed within the cuticle so that they appear twisted or folded on themselves, a condition specially marked in the third joint of the endopodite. The exopodite is not folded and is not as yet provided with the swimming-setæ so characteristic of their condition in the next stage, though these may be seen indistinctly under the cuticle as well as the segmentation of this appendage. The two powerful muscles with which it is provided for swimming purposes at the next stage are distinctly visible.

The *third walking-leg* differs from the first and second, and though long and folded on itself like them, has only the rudiment of an exopodite.

The *fourth walking-leg* is scarcely to be distinguished as a small swelling, while the fifth is not present even in rudiment.

In comparing this larva with that of other known larvæ of the Loricata we notice some striking differences. The European *Palinurus* and *Scyllarus* have been investigated by Dohrn (1), Claus (2), and Richters (3), and their

development and transition into the phyllostoma stage described. In both cases the form which emerges from the egg is a typical phyllosoma, the body is clear and transparent, the limbs are fully expanded, the various spines and swimming-setæ are fully developed. In the newly-hatched larva of *Palinurus* (*Jasus*) *lalandii*, on the other hand, it is not till the next moult that the typical phyllosoma-form is assumed and in the first free larva the cephalic region is still opaque owing to the presence of yolk, the thoracic limbs with their spines and swimming-setæ are not fully developed. In regard to these points, therefore, the naupliosoma larva corresponds to a stage passed in the egg in the case of *Scyllarus* and the northern *Palinurus*.

Again, in *Palinurus quadricornis* and *Scyllarus* the second antennæ at the time of hatching are shorter than the first, whereas in the form under consideration the first are markedly the shorter, being only about three-fourths of the length of the second antennæ. This new form further differs from the young *P. quadricornis* in having well-marked biramose antennæ, in this respect resembling *Scyllarus*. The presence or absence of marked biramose antennæ cannot therefore be taken as a means of distinguishing the larval forms of the Palinuridæ from other similar forms. This biramose condition persists in the succeeding phyllosoma stages of the Cape *Palinurus*, and is marked in the oldest undoubted phyllosoma belonging to it which I have yet found (4·4 mm. in length).

The hepatic diverticula of the naupliosoma have a much greater resemblance to those of the phyllosoma of *Scyllarus* than to that of *P. quadricornis*, there being three pairs in the first two, while, in the last, they are numerous from the very beginning.

An agreement between the first two is also seen in the absence of an exopodite in the third maxilliped, while it is present in the youngest phyllosoma of the last (taken from the egg just before hatching).

In the newly hatched larva of *Scyllarus* the 4th and 5th ambulatory legs are scarcely to be seen, while in that of *P. quadricornis* they occur as minute buds. In the naupliosoma there is only a slight trace of the 4th, in the form of a minute bud, while no traces at all of the 5th were observed, though they both appear in the stage of 4·4 mm.

Neither in *Scyllarus* nor in *P. quadricornis* are the antennæ at any stage provided with long setose swimming-processes as in the naupliosoma. It is presumed that, at one stage in its phylogeny, *Palinurus* had a free nauplius stage, whose chief organs of locomotion were the biramose antennæ and their swimming cuticular processes. The appearance of such organs at this late stage in the Cape *Palinurus* may be a new acquisition or a belated appearance of an old.

The significance of this stage of so short duration in the life-history of the Crawfish appears to be that it enables the young to ascend more rapidly, and with more certainty, to the surface than in the case with the slowly moving

phyllosoma, which is more adapted to a horizontal mode of progression. The biting and grasping setæ of the mouth-parts and other appendages are not yet developed, and the larva does not appear to feed during this stage. The Cape Crawfish occurs in great abundance on the West Coast of South Africa in marked contrast to the comparative scarcity of the European *Palinurus*. Is it possible that the occurrence of this short stage, which appears to be of a little assistance in the life-history of the animal, may have something to do with this relative abundance? If so, the Cape Crawfish might with profit be introduced into the fisheries of Europe, an undertaking which would be comparatively easy, owing to the hardy nature of this animal.

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On a Collection of Non-Marine Mollusca from the Southern Sudân. By Jane Longstaff, F.L.S. With Descriptions of Three New Species, by H. B. Preston, F.Z.S.; and Notes on *Veronicella nilotica*, by G. C. Robson, B.A.

(Plates 17, 18.)

[Read 4th December, 1913.]

Since many travellers in the region of the Upper Nile have collected mollusca, which have been recorded either by themselves or others, it might seem almost superfluous to write further on the subject. Unfortunately, however, some authors have not been careful to give exact localities, while others have founded new species on one or two specimens, or even on immature ones. It may, therefore, not be devoid of interest to have an account of a collection from the Sudân detailed both with regard to localities and numbers.

This collection was made almost entirely on the White Nile, in the years 1909 and 1912. A visit each year to the mouth of the river near Mogran was very fruitful, but still more so were two trips up the river in comfortably equipped Government steamers. The first time we went, between the 16th and 21st of February, we did not get further than Gebel Én on the right bank (lat. 12° 37′ N.). The second journey took place between February 1st and 23rd, and extended to Gondokoro in Uganda on the same bank (lat. 4° 54′ N.), and also about eight miles beyond to Rejâf on the opposite bank (lat. 4° 45′ N.), in the Lâdô Enclave, now forming part of the Anglo-Egyptian Sudân.

The distance traversed in steaming up the White Nile from Khartûm (lat. 15° 37′ N.) was 1128 miles. North of Lake No (lat. 9° 30′ N.) the river is called Bahr al-Abyad; it is fairly wide and the shores are more or less shelving. South of Lake No, where the river is called Bahr el-Gebel, we passed for many hours through the Sadd, which is composed of masses of vegetation, much of it floating; still further south the shores were usually steeper, occasionally forming cliffs, while sometimes rocks cropped out in the bed of the river.

We went a little way up the tributaries Sobat and Bahr el-Zarâfa; the latter runs almost parallel with the Bahr el-Gebel, leaving it in lat. 7° 0′ N., and entering the Bahr al-Abyad in lat. 9° 25′ N.

In addition to collecting on the White Nile I had the opportunity of spending a few hours at Sôba, about fifteen miles up the Blue Nile, in lat. 15° 32′ N., and also a short time at Khor Surkab, near Kerreri, on the united rivers below Khartûm, in lat. 15° 46′ N.

While ascending the White Nile numerous stoppages were made, and I

obtained specimens at thirty places, some of which were visited twice. Though the managers of the steamers were most obliging in trying to suit the tastes of all the passengers, these halts were only too few and too short to satisfy collectors, while sometimes the best hunting ground was just discovered as the steamer had to start again. A collection made under such circumstances cannot be exhaustive, and indeed must be regarded only as a contribution towards our knowledge of the Molluscan fauna of the region. The shells were all taken in the river or within one, or at most two, miles from its margin. Many were obtained either by means of a long handled scoop, by boys wading, or in the case of the larger ones, such as *Ætheria*, through native fishermen, who caught them in their nets. Others, again, were stranded by the subsiding water of the river, when they often contained the animal alive or but recently dead. Small gasteropods as well as the large *Ampullaria* were found on marshy ground close by, and the former also on water-plants in the river.

With regard to distribution it is unnecessary to say much here, as it is given in the notes on each species. It may, however, be pointed out that the range is interesting in a twofold way.

First, the geographical position of the Nile causes it to carry the drainage of the region of the Great Lakes down to the Mediterranean, giving rise to a commingling of Ethiopian and Palæarctic forms.

As might be expected, the freshwater molluscan fauna presents, with few exceptions, the same character throughout. But it is otherwise with the land-shells, for *Helix desertorum* is left behind and distinctly tropical forms take its place.

Secondly, there is the fact of species extending far beyond the Nile Region over the continent of Africa. Among the bivalves, *Spatha rubens*, for instance, ranges from Lower Egypt to Uganda, and also to Senegal and the Congo ; *S. wahlbergi* occurs near Khartûm and extends thence southwards to the Transvaal, as well as westwards across to the Ngadda River in Nigeria. And the large gasteropod *Burtoa nilotica* extends from the Bahr el-Gebel to Matabele Land in the south, to Lake Tchad in the west, and to the Juba River in the east.

If we consider merely the district of which I have had a more or less limited experience, we must observe that *Cleopatra bulimoides* is by far the most frequent and abundant freshwater gasteropod. It occurs in both Palæarctic and Ethiopian regions, and though so common, is interesting as exhibiting a considerable amount of variation. *Ampullaria wernei*, a distinctly Ethiopian species, is not only numerous but, on account of its great size, it is also conspicuous.

As it was the dry season terrestrial gasteropods were scarce, and they were more especially so in 1912, because there had been less rainfall than usual

during the previous rainy season. Those collected were all dead except a single specimen of *Veronicella nilotica*, Cock., found at Hillet al-Nûwêr, a small islet in the Sadd, and only one example of *Limicolaria*, which was taken at Kâkâ, contained even a dead animal. No land-shells were seen north of Abba Island (lat. 13° 22′ N.), where we met with the first specimens of *Limicolaria*, of which genus the individuals became more numerous further south. Sheik Tombê, on the Bahr el-Gebel, was the best place we stopped at for land mollusca, but unfortunately, after a violent thunderstorm there were such torrents of rain that I was unable to go ashore. I was therefore indebted to my husband and fellow-passengers for the specimens obtained.

The practice of setting fire to the vegetation in the southern districts was most detrimental to the gasteropoda, and many were more or less calcined.

No Lamellibranchiata were met with south of Lake Shâmbê with the exception of immature specimens of *Corbicula* and *Sphærium* at Gondokoro. Possibly the steep character of the shores as well as my not having facilities for deep-water dredging is answerable for this, since I always found bivalves most numerous where the margin of the river was shelving. They were especially abundant on the flat lower reaches of the Bahr al-Abyad, where wading and other birds also abounded, and probably they afforded food for the latter, for several shells taken had angular breakages as if made by birds. On the muddy flats near Mogran specimens of *Mutela* and *Nodularia* were very numerous. Quite the rarest species met with was *Pseudomutela plicata*, von Marts., of which I only obtained one example at Gebel Ahmad Aghâ.

During the present century four collections from the Upper Nile have been described, and in most cases accurate localities have been given.

The first was made by Capt. Flower, F.L.S., and recorded in the Proc. Zool. Soc. 1900, p. 970. He obtained eleven species in the Bahr al-Abyad and Bahr el-Zarâfa, none of which was new to science.

The second was the result of the Swedish Zoological Expedition to the district between Shendi, lat. 16° 42′ N., and Fâshôda (Kôdôk), lat. 9° 54′ N., during the period from February until May in 1901. Twenty species and four varieties were taken, and afterwards recorded by Herr Richard Hägg (1904). One of the latter, a variety of *Limicolaria sennaariensis*, Shutt. (*flammata*, Caill.), he regarded as new.

The third collection was made by Dr. Innes Bey on the White Nile, and described by M. Pallary (Bull. Inst. Égypt. ser. 4, no. 3, March 1902). Few of the localities visited are given, and the date is not stated. Twenty-four species are enumerated; two gasteropods are not specifically denoted; three lamellibranchs are new, and two others, *Unio euryssellinus*, Letourn., and *U. mysticus*, Bourg., have since been regarded by M. Pallary as varieties of *Nodularia nilotica*, Caill.

The fourth collection was made by Dr. Otto le Roi, of Bonn, and described by Dr. C. B. Boettger and Dr. F. Haas in Proc. Malac. Soc., Sept. 1913. Twenty-four species are recorded ; as five of these occurred in the Bahr el-Ghazâl exclusively, and two in the Nile further north, we are only concerned with seventeen. Of these one form, *Limicolaria koenigi*, is regarded as a new species.

Of course these collections have many species in common ; allowing for this we have a total of forty-four in all.

I obtained fifty-three species, as well as several varieties, on the White Nile—thirty-four species of Gasteropoda, and nineteen of Lamellibranchiata. Two are new, both Gasteropods, which occurred in the Bahr el-Gebel; one is a species of *Streptaxis*, the other of *Segmentina*. In the Blue Nile, in addition to several common molluscs, I found a new species of *Nodularia*. Four species of Gasteropoda from the Bahr el-Gebel are too imperfect to name. Six or seven other species appear to be new records for the White Nile, viz. :—*Limicolaria turriformis*, v. Marts., *L. smithi*, Preston, *Limnæa cailliaudi*, Bourg., *Isidora dybowskii*, Fischer, *Sphærium teilhardi*, Pallary, *Eupera letourneuxi*, Bourg., and perhaps *Veronicella nilotica*, Cock. It is not clear whether the last-named species occurred on the White Nile previously or not. The only record of the habitat of the holotype is "by the Nile above Khartûm." By Nile is probably meant Bahr al-Abyad, and the mollusc may well have been brought down from above by floating Sadd.

I have in addition six or seven species which have been previously recorded by earlier collectors, as well as thirty-three of the same species as those in the four recent collections just quoted. These contain also twelve species * which I did not meet with, making a grand total of sixty-five species for the White Nile exclusive of the region to the west of Lake No and south of Rejâf. Since authorities differ in opinion as to what should be regarded as a species, any numerical statement must be regarded as approximate only.

On our voyages up the White Nile our fellow-passengers were most kind in bringing me all the land-shells they found, and I must especially mention Messrs. Backhouse, Gwynne, and Wallace. I am greatly indebted to M. Pallary for naming specimens, and to Mr. E. A. Smith and Mr. Robson for their courtesy in affording me facilities for studying in the British Museum (Nat. Hist.), and to Mr. Preston for valuable assistance in many ways.

* These are *Cleopatra verreauxiana*, Bourg. (Hägg), *Bithynia boissieri*, Charp. (Hägg), *Lanistes ovum*, Peters (Boettger), *Hydrobia schweinfurthi*, Jickeli (Hägg), *Planorbis pæteli*, Jickeli (Pallary), *Isidora sericina*, Jickeli (Hägg), *Physa subopaca*, Lam. (Pall.), *Physopsis* sp. ? (Pall.), *Succinea rugulosa*, Morelet (Hägg), *Limicolaria kordofana*, Shutt. (Pall.), and *L. connectens*, von Marts. (Boettger). I have not counted *Corbicula radiata*, Parr. and *C. pusilla*, Parr., as Pallary considers them merely immature forms.

In order to save space I have only given sufficient references to identify each species. Also, with a few exceptions, only the names of works on the subject published since 1908, as Herr Hägg and M. Pallary have compiled complete lists of those prior to that date.

Class GASTEROPODA.

Order PROSOBRANCHIATA.

Suborder MONOTOCARDIA.

Section Tænioglossa.

Family Hydrobiidæ.

Subgenus Gabbia, *Tryon*.

Gabbia sennaarica, *Küster*.

Paludina sennaarica, Parreyss in Küster, 1853, 'Syst. Conchyl.-Cab.' p. 44, pl. 9. fig. 10.

Gebel Én (two), Bahr el-Zarâfa (five), small living specimens numerous amongst weeds in Lake Shâmbê, and Kanîsa (one). Confirmed by M. Pallary. He states that the species occurs "Tout le cours du Nil et de ses affluents." Bourguignat records it from Abyssinia and the Blue Nile.

The largest example was found at Gebel Én; it measures, alt. 5·75, diam. 4 mm. Another from Bahr el-Zarâfa is nearly as big, measuring alt. 5·5, diam. 4 mm.

The specimens from these two localities have the spire slightly higher than some I got in ponds near the Pyramids of Gizeh, which M. Pallary considered typical.

Family Viviparidæ.

Genus Vivipara, *Lamarck*.

Vivipara unicolor, *Oliv*.

Cyclostoma unicolor, Olivier, 1804, 1812, 'Voy. Emp. Ottoman,' vol. ii. p. 39, vol. iii. p. 68, Atlas ii. pl. 31. fig. 9.

Thirty-five specimens were taken at the following localities:—near Mogran (six), Abba Island (six), Ad-Duwêm (one), Hillet Abbâs (five), Masran Island (two), Gebel Én (three), Kôdôk (one), Wâw (one), Hillet al-Nûwêr (two), and in Lake Shâmbê (eight).

The shells from Mogran and Ad-Duwêm have smooth, convex whorls with occasional vestiges of spiral lines, or of an angle on the upper whorls, or subangularity on the body-whorl. Nearly all the rest are distinctly biangular (var. *biangulata*, Küst.) with intermediate moniliform lines. In several of the specimens from Abba Island, Hillet Abbâs, Gebel Én, Kôdôk, and Lake Shâmbê, hairs are attached to the "beads." On a shell from Kôdôk the hairs are remarkably long, some measuring 1·25 mm. in length. These hairy individuals are like those named by Frauenfeld, *V. capillata*, but since they do not differ in other respects from *V. unicolor* they can hardly be considered more than a variety. The specimens of this species I found in ponds near the Pyramids of Gizeh nearly all show traces more or less defined of moniliform spiral lines, but I did not observe hairs on any of them; of course this might arise from carelessness in cleaning them, for the hairs would be easily rubbed off.

The largest shell is from Hillet Abbâs; it measures alt. 20·5, diam. 17·5 mm. Some of the others are nearly as big.

V. unicolor is reported throughout Egypt and the whole basin of the Nile from the Victoria Nyanza, Albert Nyanza, Lake Dembea, East Africa, Lake Tchad, and Senegal. Also sub-fossil in the Fayûm.

Subgenus Cleopatra, *Troschel.*

Cleopatra bulimoides, *Oliv.*

Cyclostoma bulimoides, Olivier, 1804, 1812, 'Voy. Emp. Ottoman,' vol. ii. p. 39, vol. iii. p. 68, Atlas ii. pl. 31. fig. 6.

This species was taken at intervals along the whole length of the White Nile between the mouth near Mogran and Gondokoro. A certain amount of variation was observed, some having smooth convex whorls and others carinated ones, the spiral angle differed somewhat; also the colour varied from light horn to almost black, or there were dark stripes on a paler ground. None of these characters are of sufficient note to be deemed worthy of specific significance, but it may be of interest to record the extent of their occurrence at different localities. It will be observed that striped and keeled shells were more numerous than unicolorous smooth ones in comparison with the number taken, higher up the river than at the mouth.

Near Mogran were found one hundred and seventy-five examples; twenty-four have keels, but on only one is the keel continued to the body-whorl. Eighteen are striped, the rest unicolorous. The largest consists of six whorls, it measures alt. 16, diam. 10 mm. A more slender form has five and a half whorls which measure, alt. 12, diam. 7 mm.

Ad-Duwêm: six, only one striped.

Tawîla : eleven all dead, only six in tolerable condition, they are striped and three are bicarinate.

Hillet Abbâs : ten, all decollated, five striped, four bicarinate.

Masran Island : four, decollated and striped.

Gebel Én : seventy-eight, mostly decollated, thirty-seven with both keels and stripes, eleven unicolorous with keels, generally uncarinate, but a few bicarinate. Twenty-three simply striped.

Gebel Ahmad Aghâ : two dead, decollated and striped.

Kâkâ : nineteen decollated and some much eroded, all striped and six bicarinate.

S. of Melût : two dead, striped.

Lake Shâmbê : ten, all striped and keeled, the greater number bicarinate. Colour so dark that the stripes hardly show.

Gondokoro : one alive, more elongated than usual as the whorls are more exsert ; it is decollated, striped, and bicarinate. Alt. 14, diam. 7·5 mm. Whorls five. If this shell were compared with one of the broader forms from Mogran without the intervening links, each would probably be considered a distinct species.

Reported from Lower and Upper Egypt, the whole basin of the White Nile up to the Victoria Nyanza ; Abyssinia, Lake Rudolf, Mombassa, Zanzibar, Angola, and Senegal.

Family Ampullariidæ.

Genus Ampullaria.

Ampullaria kordofana, *Phil.*

Ampullaria kordofana, Philippi, 1851, 'Conchyl.-Cab.' ed. 2 : Genus *Ampullaria*, p. 44, pl. 13. fig. 1.

About thirty specimens were taken, many of which are immature, and in that state they are difficult to distinguish from *A. wernei*, Phil. They occurred at Tawîla, Kosti, Hillet Abbâs, Masran Island, Gebel Én, Renk, south of Melût, Bahr el-Zarâfa (southern end), and Hillet al-Nûwêr.

An example from Kosti, having the apex broken and four whorls intact, measures alt. 66, diam. 56·5; aperture, alt. 48, diam. 30 mm.

A specimen from the Bahr el-Zarâfa has a higher spire than usual and thus resembles a variety called *elongata* by Rochebrune and Germain (Mém. Soc. Zool. France, 1904, vol. xvii. p. 5). They state that their shell corresponds with that figured by Bourguignat in Moll. Nouv., Litig. &c., 1863, p. 78, pl. 11. fig. 13. The dimensions they give are alt. 70–78, diam. 65–69; aperture, alt. 50–55, diam. 35–38 mm. Locality, River Omo, at a height of

600 metres. My specimen is larger but has much the same proportions; it measures, alt. 82, diam. 70 ; aperture, alt. 56, diam. 37 mm. It has only three whorls preserved, the apex being broken.

This species is common in all the lakes and rivers of Egypt as well as throughout the whole Nile basin ; it also occurs in Abyssinia. It has thus a more extended range northwards than *A. wernei*.

Ampullaria wernei, *Phil.*

Ampullaria wernei, Philippi, 1851, 'Conchyl.-Cab.' ed. 2: Genus *Ampullaria*, p. 19, pl. 5. fig. 4, and pl. 17. fig. 2.

About fifty specimens were taken. The species occurred throughout the course of the White Nile traversed, namely at Abba Island, both opposite Fashi Shoya and also at Tawîla, Kosti, Hillet Abbâs, Gebel Én, south of Melût, Lûl, Wâw, Taufikîyâ, Dûlêb (Sobat River), Bahr el-Zarâfa, Lake Shâmbê, Kanîsa, and Rejâf Wooding Station. I am uncertain whether to refer a number of immature shells found at Malek to this species or to *A. kordofana*.

A large individual from Hillet Abbâs consisting of six whorls measures, alt. 103, diam. 97 ; aperture, alt. 77, diam. 45 mm. It was alive, as well as another nearly as big. Shells from Tawîla almost equal these in dimensions, and the operculum belonging to a still larger shell was found at Gebel Én.

A. wernei has been reported from near Kassala to the north and throughout the basin of the Upper Nile southward to the Great Lakes, as well as westward in the Bahr el-Ghazâl and Chari River. Von Martens mentions a variety which was collected by Prof. Peters in Querimba Island.

Lanistes carinatus, *Oliv.*

Cyclostoma carinata, Olivier, 1804, 1812, 'Voy. Emp. Ottoman,' vol. ii. p. 39, vol. iii. p. 68, Atlas ii. pl. 31. fig. 2.

This species was found at intervals throughout nearly the whole distance traversed, namely at Ad-Duwêm, Abba Island, Kosti, Hillet Abbâs, Masran Island, Gebel Én, Renk Wood Station, Mashra Zarâfa Wood Station, Kâkâ, S. of Melût, Kôdôk, Lûl, near each end of the Bahr el-Zarâfa, Lake Shâmbê, Kanîsa, Malek, and Sheik Tombê. Of the sixty specimens taken, many were living ; the largest, however, which is from Kâkâ, was dead and devoid of epidermis.

Lanistes carinatus occurs both in Lower and Upper Egypt ; in the Sudân being reported from Sennaar on the Blue Nile, and the Bahr el-Ghazal as well as its tributary the Djur, and, as noted above, in the White Nile up to the borders of Uganda, in the Victoria Nyanza, Lake Dembea, and as far east as the Tana River. It also is found fossil in Recent and Post-Pliocene deposits in Egypt, and in Miocene beds near the Victoria Nyanza.

Subgenus Lanistes, *Montfort*.

Lanistes innesi, *Pallary*.

Lanistes innesi, Pallary, 1902, Bull. Inst. Égypt. ser. iv. no. 3, p. 91, pl. 1. fig. 2.

Fourteen specimens were found at a short distance from the mouth of the Bahr el-Zarâfa, all dead, only one with the epidermis well preserved and three with fragments of it. The umbilicus varies in different individuals ; in two it is completely covered by the reflection of the inner lip, in two uncovered, and in the rest it is partially covered. It greatly resembles *L. purpureus*, Jonas (*Ampullaria purpurea*, 1839, Archiv f. Naturgesch. vol. i. p. 342, pl. 10. fig. 1), and may be a variety of that species. It is distinguished by the spire having the contour less flattened, the whorls more convex, sutures deeper, and the lines of growth coarser. The height of the spire varies somewhat ; the best preserved specimen measures alt. 51·5, diam. 40 mm. ; whorls six. The largest measures alt. 56, diam. 40 mm.; whorls seven.

The holotype was obtained by Dr. Innes Bey on the White Nile, but the exact locality is not given. I have seen the shells in the British Museum (Nat. Hist.) taken by Captain Flower in the Bahr el-Zarâfa which were referred by him to *L. purpureus*, and I find that they are conspecific with *L. innesi*, Pallary.

Family Melaniidæ.

Genus Melania, *Lamarck*.

Melania tuberculata, *Müll*.

Nerita tuberculata, Müller, 1774, 'Verm. Terr. et Fluv. seu Anim. Infus., Helmin. et Testac., non Marin., Succ. Hist.' vol. ii. p. 191.

This widely distributed species was taken near Mogran, at Ad-Duwêm, Tawîla, Masran Island, Gebel Én, Kâkâ, near Melût, in Lake Shâmbê, where it was especially numerous, and at Gondokoro.

All the specimens are decollated except a few very young ones which have the protoconch preserved.

Order PULMONATA.

Suborder **BASOMMATAPHORA.**

Family Limnæidæ.

Genus Limnæa, *Lamarck*.

Limnæa cailliaudi, *Bourg*.

Limnæa cailliaudi, Bourguignat, 1883, 'Hist. Mal. Abyssinie,' pp. 89, 90, figs. 100–101.

Five living specimens were found : at Gebel Én (two), Bahr el-Zarâfa (two),

and at Hillet al-Nûwêr (one). They were near the edge of the river and are small. M. Pallary, who kindly examined them, considers them immature. One from Gebel Én has the spire more produced and resembles *L. acroxa*, Bourg. (op. cit. fig. 94), which M. Pallary also thinks is an immature stage of this species. He states that *L. cailliaudi* is found in the "Cours du Nil Bleu et du Grand Nil." He has not, however, recorded it in his descriptions of the Innes Bey Collection; neither has the Swedish Expedition noted its occurrence in the White Nile. Bourguignat reports it in addition from Lake Dembea.

This seems to be a new record of its existence in this region.

Genus Planorbis, *Guettard.*

Planorbis boissyi, *Pot. et Mich.*

Planorbis boissyi, 1838, Potiez et Michaud, 'Galerie de Douai,' vol. i. p. 208, pl. 21. figs. 4-6.

I met with this species both to the north and south of Lake No, and took eighteen specimens in all: at Abba Island (two), Hillet Abbâs (four), Gebel Én (five), north end of Bahr el-Zarâfa (three), south end (one), and Hillet al-Nûwêr (three). The Swedish Expedition appear to have been the first to find it in the White Nile, and they obtained numerous young examples at Gebel Ahmad Aghâ, none of which is as large as my biggest, which measures, alt. 3·5, diam. 12 mm. This species is also recorded from Lower Egypt.

Planorbis mareoticus (*Letourn. MS.*), *Innes.*

Planorbis mareoticus, 1884, Walter Innes, Bull. Soc. Malac. France, vol. i. p. 339.

Only one dead specimen in Lake Shâmbê, which I sent to M. Pallary, who kindly determined it. He had previously recorded some examples of the species found by Dr. Innes Bey in the marshes of the White Nile.

It is doubtful whether this should be separated from *P. ehrenbergi*, Beck (*P. cornu*, Ehrenb.). Dr. Innes Bey and M. Pallary consider the species distinct, restricting the name *ehrenbergi* to specimens with convex whorls and *mareoticus* to those with sharply keeled whorls. Jickeli and M. Ancey regard them as conspecific because there are numerous intermediate forms.

Prof. Schweinfurth took specimens of *P. cornu*, Ehrenberg (which is probably identical with this) in the Bahr el-Ghazâl. It also occurs in Lower Egypt.

PLANORBIS COSMIUS, *Innes*.

Planorbis cosmius, 1884, Walter Innes, Bull. Soc. Malac. France, vol. i. p. 335.

I took but a single specimen of this small form at Kanîsa, which I sent to M. Pallary, as I thought it might be the same as some examples from the White Nile referred to by him in Bull. Inst. Égypt. p. 90, which he did not name. He replied that it was conspecific and suggested my comparing it with *P. cosmius*, Innes. It agreed with the description by Dr. Innes Bey, who considers the species to be the Egyptian representative of *P. spirorbis*. I therefore compared it with British specimens of that species, and found that it comes nearest to the variety *ecarinata*, Jeffr.; it is, however, lower, and the last whorl is wider. Jickeli * writes of a new species of *Planorbis* having very narrow flat whorls which was found by Prof. Schweinfurth in the Bahr el-Ghazâl. This also may possibly be *P. cosmius*.

Dr. Innes Bey had previously found other specimens near Ramleh.

Subgenus SEGMENTINA, *Fleming*.

SEGMENTINA ANGUSTA, *Jickeli*.

Four specimens were met with. Bahr el-Zarâfa (one living), Hillet al-Nûwêr (one dead), Kanîsa (two living). The largest has a diam. of 3·5 mm. Jickeli states that this species is very rare; he reports it from the White Nile, Bahr el-Ghazâl, and Abyssinia. Dr. Boettger received one example only from the Bahr el-Ghazâl.

SEGMENTINA KANISAËNSIS, sp. nov.

Five examples taken in marshy pools near the river at Kanîsa.

A description by Mr. Preston is given in Appendix I., p. 265.

Genus ISIDORA, *Ehrenberg*.

ISIDORA BROCCHII, *Ehrenb*.

Isidora brocchii, Ehrenberg, 1831, 'Symb. Phys.' No. 2.
Physa brocchii, Bourguignat, 1862, 'Paléontol. Alg.' p. 84, pl. 5. fig. 20.

Two examples from Gebel Én. The largest measures, alt. 7·5, diam. 4·75 mm. Bourguignat gives alt. 8–10, diam. 6–7 mm.

This species is chiefly distinguished from *I. truncata* by its higher spire and narrower body-whorl.

It has been reported from Egypt, Algeria, and Syria.

* 'Fauna der Land- u. Süsswasser-Mollusken N.O.-Afrikas,' Nova Acta der K. Leop.-Carol. Deutsch. Akad. d. Naturf. vol. ii. 1874, p. 217.

Isidora truncata (*Fér.*), *Bourg.*

Physa truncata, Férussac, Audouin, 1826, 'Explic. Sommaire des Planches Moll. Égypte et de la Syrie par Savigny,' vol. i. pl. 4, p. 33. Savigny, 'Descr. de l'Égypte,' 1812, pl. 2. fig. 27.

Physa truncata, Bourguignat, 1856, 'Amén. Malac.' vol. i. p. 176, pl. 21. figs. 5–7.

Four specimens were found at Hillet Abbâs and two at Gebel Én on water-plants at the edge of the river. They were previously mistaken for *I. sericina*, Jickeli ('Butterfly Hunting in Many Lands,' by G. B. Longstaff, 1912, p. 424), which had been recorded from the district by Herr Hägg. They have, however, a much flatter spire and a longer body-whorl.

The largest example is from Hillet Abbâs; it measures, alt. 9·25, diam. 6 mm. The smallest, from Gebel Én, has an alt. of 6 mm.

Jickeli unites *I. truncata* with *I. contorta*, Mich., considering it a young stage of that species, but this can hardly be the case for they differ in form, and my biggest shell exceeds in size the dimension he quotes for *I. contorta*. It may more probably be a variety of *I. brocchii*, Ehrb., to which it bears a greater resemblance, as they both have a narrower aperture than *I. contorta*.

Bourguignat states that it is widely spread in Syria and Egypt and that it occurs both living and fossil in Algeria. Germain records it from Lake Tchad.

Isidora contorta, *Mich.*

Physa contorta, Michaud, 1829, Bull. Soc. Linn. Bordeaux, vol. iii. p. 268, figs. 15, 16.

Only one specimen was found, on Masran Island, but many were taken in Lake Shâmbê, most of which were immature. Three or four shells have strong raised threads running down the whorls along the course of the lines of growth.

This species was previously found in the White Nile by Prof. Schweinfurth and recorded by von Martens. It has a very wide range, being reported from Southern Europe, North, West, and South Africa, Abyssinia, and the Euphrates.

Isidora dybowskii, *Fischer*, var.

Bullinus dybowskii, Fischer, 1891, 'Moll. Miss. Dybowsky,' p. 365, pl. 3. figs. 4, 4 *a*.

A single example was taken alive at Kâkâ. It appeared to me like the shell figured by M. Pallary in 'Cat. Faune Malac. Égypte,' pl. 3. fig. 34, as a variety of *Isidora dybowskii*. I therefore sent it to him, and he confirmed my identification and stated that it was not quite mature. This is a new record of the species in the White Nile.

It has previously been found in Lower Egypt, and also sub-fossil in the Algerian Sahara at El Goléa (*Pallary*).

Isidora (Pyrgophysa) forskali, *Ehrb.*

Isidora forskali, Ehrenberg, 1831, 'Symb. Phys.' No. 3, p. 174.

One specimen was found alive in Lake Shâmbê. It is of medium size, consisting of four and a half whorls which measure, alt. 6·75 mm.

The species is reported from North, East, West, South, and Central Africa, Aden, Mauritius, and the Cape Verde Islands.

Suborder **STYLOMMATAPHORA.**

Family Testacellidæ.

Streptostele? sp.

One dead specimen at Sheik Tombê.

Streptaxis? sp.

Four dead shells at Sheik Tombê too imperfect to identify.

Streptaxis sudanica, sp. nov.

Three specimens at Sheik Tombê. A description by Mr. Hugh Preston will be found in Appendix I., p. 265.

Family Limacidæ.

Helicarion? sp.

One dead specimen at Sheik Tombê.

Martensia sp.

Two dead immature shells at Rejâf Wooding Station. Four in similar condition, probably the same species, found among scrub at Rejâf.

Family Stenogyridæ.

Genus Limicolaria, *Schumacher.*

Limicolaria flammata, *Caill.*

Cochlogena flammata, Cailliaud, 1823, 'Voyage à Méroë,' vol. ii. pl. 60. figs. 4, 5, vol. iv. 1827, p. 265.

I obtained about eighty specimens of this species. They show a considerable amount of variation, and at localities where a series was taken shells of the stouter typical form were associated with others varying in their degree of slenderness.

Now a slender form has been described by Shuttleworth * under the name of *candidissima*, and it is represented as pure white in the figures, though he states there are traces of straw-yellow streaks on the last whorl, and that the epidermis is thin, pale, and horny. He had only one example, which was from Kordofan.

Von Martens † refers to the traces of brown streaks on this specimen, though at first sight it appears white, and he regards these streaks as similar to those on *L. cailliaudi*, Pfeiff. (*L. flammata*). Jickeli ‡ also states that, though he has figured a unicolorous example, he has specimens before him with stripes more or less the same as those on *L. sennaariensis*, Shutt. (*flammata*).

Von Martens § has described and figured a small shell from the Bahr el-Ghazâl resembling *L. candidissima* in shape, but smaller and having very decided brown streaks, as variety *gracilis*.

Still another elongated shell has been described by Dr. Pilsbry ‖ from the Omo River, similar to the last in form and colour, but more elongated ; it is named var. *smithi*.

The streaks or flammules with which the shells of this group are ornamented vary in width, distance apart, and also in depth of colour, which may be light yellowish-brown, dark brown, or almost black. Owing to the habit that molluscs have of burying themselves in the earth, it is common to find shells, both stout and slender, bleached on one side, while more or less of the epidermis and flammules may be preserved on the other.

It is most unfortunate that a name of the significance of *candidissima* should have been given to a holotype ; also it is unfortunate that the representative of the var. *gracilis* should have been a small form. Since Jickeli and M. Pallary both comprise the slender shells agreeing in shape, whether striped or unicolorous, under the varietal name of *candidissima*, I think it advisable to follow their example.

In my collection the groups found at different localities, besides varying among themselves in the width of the spiral angle, have also each a distinctive facies, showing slight differences in form and colour according to their respective habitats.

In consequence of this fact, I consider it most convenient to record the specimens topographically, when I shall reserve the word *holotype* to signify *L. flammata*, sensu stricto.

It would of course be possible to make a number of sub-varieties based on slight peculiarities, but these would be of no value without a knowledge of

* 'Notit. Malac.' vol. i. 1856, p. 49, pl. 6. figs. 7, 8.
† Malak. Blätt. 1865, p. 197.
‡ 'Fauna Land- u. Süsswasser-Moll. N.O.-Afrikas,' p. 161.
§ Malak. Blätt. vol. xvii. 1870, p. 34.
‖ 'Man. Conch.' vol. xvi. 1904, p. 283, pl. 22. figs. 37, 38.

the different animals. As most collectors visit these regions during the dry season, it is difficult to obtain living specimens.

Gebel Én: one example similar to the holotype but bleached, alt. 61, diam. 25 mm.

Renk: here I secured thirteen specimens especially characterised by their large size and distinct light brown flammules. The biggest has ten whorls, and measures, alt. 75, diam. 30, apert. alt. 28, diam. 13 mm. This is really a large typical specimen; it is similar to a shell figured by Dr. Kobelt (Martini u. Chemnitz, Syst. Conch.-Cab. ed. 2, vol. i. p. 71, pl. 23. fig. 3), which he regards as a variety of *L. sennaariensis*. The longest shell measures, alt. 79, diam. 28; apert. alt. 28, diam. 12 mm. This is slightly larger than fig. 4 of Dr. Kobelt. Another individual is still more slender, measuring alt. 70, diam. 24 mm. Specimens were taken by Herr Hägg at this locality, one of which he refers to Dr. Kobelt's fig. 4 and names var. *crassior*. His shell has the aperture somewhat wider than mine.

Mashra Zarâfa: nine examples all slender, two with slightly convex whorls and especially resembling var. *candidissima* in shape, but distinctly streaked with brown. The others have more flattened whorls: one is semi-transparent and pure white; it is, however, uncertain whether it is really an albino. It measures, alt. 48, diam. 18 mm.

Kâkâ: seven very beautiful shells. One is typical, the others are more slender; they are distinguished from those from Renk by having the body-whorl more flattened and elongated. They have on the whole rather broad distinct brown flammules; on one example, however, these are finer and more broken. This last has nine whorls, which measure alt. 69, diam. 25 mm. Another shell is bleached, with only faint yellowish flammules on the body-whorl; it is almost identical in shape and dimensions with Shuttleworth's figure of the holotype of *L. candidissima*.

Kôdôk, one; Lûl, one, bleached; Dûlêb, one good example of the typical form and one of var. *candidissima*.

Lake Shâmbê: here we have a very distinct group of five shells possessing especially dark flammules close together, somewhat convex whorls, with an impressed line below the suture on the body-whorl, which in two cases has begun on the penultimate whorl. All are referable to the holotype, but they vary slightly in their spiral angle. The broadest measures, alt. 54, diam. 23 mm.; a more slender shell has an alt. of 60·5 mm. with the same diameter.

Kanîsa, two of typical form; Malek, one, var. *candidissima*; Sheik Tombê, one; Kîrô, one; Mongalla, six specimens, of which five are small typical examples, the sixth is more elongated, alt. 55, diam. 20·5 mm., and is very like Dr. Pilsbry's figure of the var. *smithi*; Lâdô, three near the holotype.

Rejâf Wooding Station: about twenty, mostly young, two typical, the others

more slender, the largest of these greatly resembles the figure of *gracilis*, v. Marts.; it measures, alt. 43, diam. 17, apert. alt. 17·5, diam. 7·5 mm., but it is not mature.

Other slender forms of this group are *L. longa*, Pilsb., and *L. koenigi*, Boettger, neither of which have I met with.

The holotype of *L. flammata* is from Mouna, a few miles north of Sennaar on the Blue Nile. This species, or one of its varieties, ranges southwards from this locality to the Lakes Albert and Tanganyika, also to the district between the Lakes and Zanzibar, and eastwards to Abyssinia.

LIMICOLARIA HEUGLINI, *von Martens*.

Achatina (*Limicolaria*) *heuglini*, von Martens, 1866, Malak. Blätt. vol. xiii. p. 94, pl. 4. figs. 1, 2.

Three specimens were found at Hillet al-Nûwêr. They may be distinguished from *L. flammata*, var. *gracilis*, v. Marts. by their flatter spire and lower penultimate whorl.

The holotype came from Southern Abyssinia. The species was taken by Dr. le Roi on the Bahr el-Gebel and the Bahr el-Ghazâl; also in the latter district by Dr. Schweinfurth.

My largest example measures, alt. 34, diam. 16 mm. Von Martens' longest shell measures, alt. 35, diam. 16 mm.

LIMICOLARIA KAMBEUL, *Brug.*, var. TURRIS, *Pfeiff.*

Bulimus kambeul, Bruguière, 1789, 'Enc. Méth.' vol. vi. pt. i. p. 332.
Var. *turris*, Pfeiffer, 1861, Proc. Zool. Soc. London, p. 25, pl. 2. fig. 3.
Limicolaria adansoni, Jickeli, 1874, 'Fauna L. u. S. Moll. N.O.-Afrikas,' p. 154, pl. 6. figs. 3 & 4.

Two large and two very small specimens were found at Rejâf Wooding Station, also ten immature ones five miles further south at Rejâf. Some examples are bleached, but on others the periostracum with its deep brown flammules is well preserved. The two larger shells agree with Pfeiffer's figure, and also with Jickeli's figures 3 and 4 on pl. 6 (*op. cit.*), which he calls *L. adansoni*, Pfr., and considers identical with *L. turris*, Pfr. Pilsbry *, however, regards *L. adansoni* and *L. turris* as distinct varieties of *L. kambeul*, Brug., the former being the western, and the latter the eastern variety. My two larger specimens measure respectively, alt. 113, diam. about 52 mm. (last whorl broken); alt. 95, diam. about 50 mm., alt. of aperture 46, diam. of apert. 24 mm. (peristome and base broken).

Dr. Boettger † records that Dr. le Roi found four specimens in this district, one at Rejâf, two at Kîrô, and one at Gemesa (Kanîsa ?).

* Tryon, 'Man. of Conch.' ser. ii. 1904, Pulmonata, vol. xvi. p. 252, pl. 25. figs. 9, 10, 11.
† Proc. Malac. Soc. 1913, vol. x. pt. vi. p. 355.

This variety is reported from the sources and tributaries of the Upper Nile, and also from Lake Tchad.

M. Germain states that it has been taken at Querké, on the French border of Liberia.

LIMICOLARIA TURRIFORMIS, *von Martens*.

Limicolaria turriformis, von Martens, 1895, Nachrichtsbl. Mal. Ges. p. 182; von Martens, 1898, Deutsch-Ost-Afrika, Bd. iv. Beschalte Weichthiere Ost-Afrikas, pp. 102, 103, pl. 4. figs. 11, 13, & 15.

A single specimen was found at Sheik Tombê. It appears to be intermediate in form between the varieties *neumanni*, v. Marts. and *solida*, v. Marts. Alt. 63, diam. 29; aperture, alt. 27, diam. 14 mm.

This species has been recorded previously from the neighbourhood of the Victoria Nyanza, whence came the holotype and two varieties just quoted; also from Lake Tchad, but apparently not from the Bahr el-Gebel.

LIMICOLARIA ROHLFSI, *Kob.*

Limicolaria rohlfsi, Kobelt, 1895, 'System. Conch.-Cab.' von Martini und Chemnitz, p. 72 & pl. 23. figs. 5, 6.

This species was taken at Hillet Abbâs (two), Hillet al-Nûwêr (four), south end of the Bahr el-Zarâfa (five), Malek (one), Sheik Tombê (two), and Kîrô (four), making in all eighteen specimens. Dr. le Roi also found it at Tombê and Gemesa (Kanîsa?). The holotype came from the Ngadda River, and the species is further reported from the neighbourhood of the Victoria Nyanza, Albert Nyanza, and Albert Edward Nyanza. My largest specimen is from Hillet Abbâs; it measures, alt. 42·5, diam. 18 mm.

The occurrence at this locality is interesting, as it does not appear to have been previously recorded so far north.

The type measures, alt. 38, diam. 17 mm.

LIMICOLARIA SMITHI, *Preston*.

Limicolaria smithi, Preston, 1906, Proc. Malac. Soc. London, vol. vii. pp. 89, 90.
Limicolaria prestoni, Boettger, 1913, ibid. vol. x. pt. vi. p. 359.

Four specimens were found at Sheik Tombê and one at Malek.

The holotype is from the northern shore of Victoria Nyanza. Mr. Preston informs me that numerous other examples in different stages of growth have been obtained in Uganda.

Genus Burtoa, *Bourguignat*.

Burtoa nilotica, *Pfr.*

Bulimus niloticus, Pfeiffer, 1861, Proc. Zool. Soc. London, p. 24.
Limicolaria nilotica, Pfeiffer, 1876, 'Nov. Conch.' vol. iv. no. 676, pl. 110. figs. 1, 2 3, p. 5.

This species was only met with on the Bahr el-Gebel. Thirteen specimens were taken : near Lake Shâmbê (one), at Malek (six), Sheik Tombê (three), Kîrô (one), and at Lâdô (two). All were dead, and only two from Malek have the epidermis preserved ; a bleached shell from this locality has the peristome greatly thickened.

Burtoa nilotica is a very variable species, and some of the forms have received distinct names.

Dr. Boettger records two specimens from near Gemesa (Kanîsa ?) on the Bahr el-Gebel, and von Martens reports it from the Bahr el-Ghazâl. It occurs throughout the Lake Region, and has been found as far south as Matabeleland (*Conolly*). Mr. Preston informs me he has taken it at Kismayu, while Germain records it from Lake Tchad.

Family Succineidæ.

Genus Succinea, *Draparnaud*.

Succinea cleopatræ, *Pallary*.

Succinea cleopatræ, Pallary, 1909, 'Cat. Faune Malac. Égypte,' Mém. Inst. Égypt. vol. vi. fasc. i. p. 45, pl. 3. figs. 29, 30.
Succinea ægyptiaca, Ehrenberg, 1830, 'Symb. Phys.'
Succinea indica, Jickeli, 1874, 'Fauna N.O.-Afrikas,' p. 167, pl. 6. fig. 11 (non Pfeiffer).

Two specimens were found at Gebel Én under a log near the edge of the river, one alive, the other dead. They agree with the figures of M. Pallary and also with that of *S. indica*, Jickeli, which species M. Pallary considers distinct from *S. indica*, Pfeiff., therefore he has given it the above name. At the same time he states that it is probably conspecific with *S. ægyptiaca*, Ehrenberg, but as this species was described from an immature specimen it is hardly possible to refer other shells to it with certainty.

It occurs near Alexandria and Damietta. If conspecific with *S. ægyptiaca*, Ehrenb., it has previously been taken in the White Nile by Prof. Schweinfurth and recorded under that name by von Martens in Malak. Blätt. 1873, p. 41.

Family VAGINULIDÆ.

Genus VERONICELLA, *Blainville.*

VERONICELLA NILOTICA, *Cockerell.*

A second specimen of this rare species was taken at Hillet al-Nûwêr, about which Mr. Robson gives further details in Appendix II., p. 266.

Class PELECYPODA.

Order EULAMELLIBRANCHIATA.

Suborder SUBMYTILACEA.

Family ÆTHERIIDÆ.

Genus ÆTHERIA, *Lamarck.*

ÆTHERIA ELLIPTICA, *Lamarck.*

Ætheria elliptica, Lamarck, 1807, Ann. Mus. Hist. Nat. Paris, vol. x. p. 401, pl. 29 and pl. 30. fig. 1.

Numerous specimens were taken at Ad-Duwêm, Abba Island, Masran Island, Gebel Én, near Gebel Ahmad Aghâ, and at Mashra Zarâfa Wood Station. At several places clusters were observed formed of examples of both the smooth, typical form, and the variety *tubifera,* Sowerby*, adhering together, this variety being generally the more abundant. The theory that the latter is characteristic of calm and the former of more turbulent waters can hardly be maintained. This species varies not only in ornamentation but also in shape, and sometimes the shells form such masses as to be an impediment to navigation.

Ætheria elliptica has been recorded from the whole Nile basin, the Lakes Victoria, Tanganyika, Dembea, Rudolf, and Tchad; from the Blue Nile, where I, as well as other collectors, have also taken it; and from West Africa; a very similar form is stated to occur in the Congo.

* Zool. Journ. vol. i. 1825, p. 523, pl. 19.

Family Unionidæ.

Genus Nodularia, *Conrad.*

Section **Cælatura**, *Conrad.*

Nodularia (Cælatura) nilotica, *Caill.*

Unio niloticus, Cailliaud, 1823, 'Voyage à Méroë,' vol. ii. pl. 61. figs. 8, 9; vol. iv. p. 263.
? *Unio sennaariensis*, Küster, 1862, 'Conch.-Cab.' p. 280, pl. 94. fig. 6.

Abundant in the lower part of the Bahr al-Abyad, where I found a hundred and forty-two specimens; the greater number occurred at Mogran and Ad-Duwêm, only four were taken on Abba Island and one at Kosti. All are small, and few, if any, mature, but some have such a remarkably thick test that it is possible they may be a dwarf form which never attains full dimensions.

M. Pallary lays great stress both on the colour of the nacre, and the presence of wrinkles (flabellations) as characters essentially separating the species *N. nilotica* and *N. ægyptiaca* from one another. I have, however, found the colour too variable to be a distinction of specific value.

Sixty-six of the specimens I took have the nacre salmon-pink, twenty-six purplish-pink, and fifty white.

The absence of wrinkles is possibly more constant, for I have not observed them on any of the White Nile examples of *N. ægyptiaca*, nor on those I found in ponds near the Pyramids of Gizeh. They are generally present on *N. nilotica*, sometimes on both ends, at other times on one end only, or they may be absent altogether.

I obtained fair-sized specimens of *N. nilotica* at Manshiya, near Mena, fourteen in number, ten with purplish-pink nacre and four white.

I also got twelve examples from the same locality of a form which M. Pallary has figured as *N. gaillardoti*, Bourguignat MS. They appear to me more worthy of ranking as a variety than a distinct species, for there are shells intermediate in character which it is very difficult to place. With one exception these have all purplish-pink nacre. I also obtained two remarkably short specimens. M. Pallary has suggested that *N. gaillardoti* may be an intermediate form between *N. nilotica* and *N. parreyssi*.

The examples of *N. nilotica* from the White Nile show a certain amount of variation. M. Pallary informs me that two have received distinctive names from Bourguignat: one which occurred at Ad-Duwêm was called *Unio eurys-sellinus*, and M. Pallary has figured it (Bull. Inst. Égypt. ser. iv. no. 3, p. 94, pl. 2. fig. 4). The other, a swollen, sub-quadrate form, was named *U. phibsicus* or *emeritus* in lit. I found it both at Mogran and Ad-Duwêm; an example from Mogran measures long. 37, alt. 24, crass. 16·5 mm. One of the former measures, long. 36, alt. 23, crass. 14·5 mm.

Unio sennaariensis, Küster (fig. 6), is also probably an immature form of this species. Herr Boettger regards it as a variety and records a single specimen from Gebel Ahmed Aghâ.

Some of the shells have the dorsal margin lower posteriorly than *U. eurysellinus*, and come nearer to the type in form. These generally have the nacre either white or tinged with salmon-pink within the umbo.

It would be unwise to found new varieties on any of these shells since neither Bourguignat's nor mine are quite mature.

The largest specimen I got at Manshiya measures, long. 54, alt. 31, crass. 24 mm. Herr Hägg states that the Swedish Expedition obtained twenty specimens, of which the dimensions exceed any that I have found in either district, having long. 73·5, alt. 42, crass. 32 mm.

The holotype is from Joseph's Canal, Lower Egypt. The species is reported from Upper Egypt, also previously from the White Nile, and Mr. A. E. Smith has recorded it from Lake Tanganyika.

NODULARIA (CÆLATURA) ÆGYPTIACA, *Cailliaud.*

Unio ægyptiacus, Cailliaud, 1823, 'Voy. à Méroë,' vol. ii. pl. 61. figs. 6, 7; 1827, vol. iv. p. 263.

I found this species less numerous but more widely distributed than *N. nilotica*. Sixteen specimens were taken, none are mature; the shell structure is thin, externally brownish green in colour, the nacre is pinkish purple, in some examples the pink tone predominates and in others the blue. No wrinkles ("flabellations") observed.

The largest specimen was found at Mogran; it measures, long. 40, greatest alt. 28, crass. 16 mm. Others occurred at Ad-Duwêm, Tawîla, Kosti, Hillet Abbâs, Masran Island, south of Melût, Wâw, Taufikîyâ, and Lake Shâmbê.

This species has been reported from Upper and Lower Egypt, in which district I have also taken examples, the Upper Nile basin, and Central Africa.

Var. SHAMBIENSIS, var. nov. (Pl. 18. figs. 4–7.)

Diagnosis.—More oval in contour than the type, more swollen, dorsal margin more curved. Exterior brown, the nacre varies from pink to purple, in two it is rose-pink merging into salmon-pink within the umbo, while in another it is bluish-white with salmon-pink within the umbo. Some of the examples are remarkably solid, and when this is the case the lamellar anterior teeth of the right valve become greatly thickened, divided, and jagged.

This is a very distinct form having the muscle-scars and the teeth, when the test is thin, of *N. ægyptiaca*, while the shape is something like *N. nilotica*, but none of the specimens has the wrinkles of that species. The higher posterior rostrum distinguishes it from *N. parreyssi*, though the teeth when the test is thick resemble those of that species.

I sent examples to M. Pallary, and he suggested it might be a variety of *N. rugifer*, Küster, who, however, calls his species the "runzeltragende Flussperlmuschel," and as I have just remarked, my shells have no wrinkles; the shape also is different, the umbo being further from the anterior end, the hinge-line shorter, and the posterior slope more gradual.

Dimensions.—One specimen measures, long. 39·5, alt. 23, crass. 16·5 mm Another is slightly shorter, the long. being 38 mm., while the alt. and crass. are the same.

Locality.—Lake Shâmbê. Eighteen individuals.

NODULARIA (CÆLATURA) PARREYSSI, *Philippi*. (Pl. 18. fig. 8.)

Unio parreyssi, v. d. Busch in lit., Philippi, 1848, 'Abbildg. Beschreib.' vol. iii. p. 81, pl. 5. fig. 6.

Unio parreyssi, Küster, 1862, 'Conch.-Cab.' p. 268, pl. 90. fig. 6.

? *Unio sennaariensis*, Küster, *ibid.* p. 280, pl. 94. fig. 5 (non fig. 6).

About ninety specimens were taken between the mouth of the White Nile and Lake No, at the following localities: Mogran, Ad-Duwêm, Tawîla on Abba Island, Masran Island, Gebel Én, Mashra Zarâfa Wood Station, south of Melût, and Taufikîyâ.

Philippi states that it occurred at Sennaar, White Nile (*Kotschy*).

It has also been recorded from the Bahr el-Ghazâl by von Martens. The Swedish expedition found only one example in the White Nile, for which no locality is given. According to M. Pallary, "Très commun dans tout le cours du Nil et de ses dérivés."

This species may be distinguished from *N. nilotica*, Caill., with which it has been united by some writers, by its more curved dorsal margin, lower posterior rostrum, more flattened and generally more eroded umbo, the most swollen part of the valve being lower, and by the thick and frequently jagged anterior tooth in the right valve. The wrinkles vary as in *N. nilotica*. A young specimen from Mogran is remarkable for having wrinkles over the umbo as well as on both ends. The colour of the nacre, however, is rarely so deep in tone: it is white, white tinged with blue, purplish pink, coral pink, or orange, the richest colour being within the umbo. The exterior is dark brown, sometimes with a greenish or yellowish tint. It differs from *N. mossambicensis*, Peters, in having the anterior end shorter and lower.

Philippi's holotype measures, long. 42, alt. 25, crass. 16 mm.

One of my shells from Ad-Duwêm measures, long. 39·5, alt. at umbo 22·5, greatest alt. 24·25, crass. 17 mm.

A large individual from Mashra Zarâfa Wood Station is dead and somewhat worn, and I feel doubtful about referring it to this species, but it appears more like it than any other. It measures, long. 43·5, greatest alt. 26·5, alt. at umbo 25·5, crass. 19 mm.

This species shows a certain amount of variation in form. Von Martens (Malak. Blätt. vol. xxi. 1873, p. 43) refers to a small specimen found by Prof. Schweinfurth in the Bahr el-Ghazâl as *Unio sennaariensis*, var. *schweinfurthi*, but as there is only one he hesitates about founding a new species on it. Later, in 'Nov. Conch.' of Pfeiffer, vol. iv. 1876, p. 140, pl. 132. figs. 3–5, he describes it as *Unio parreyssi*, var. *schweinfurthi*. Unfortunately the shell is immature ; it resembles several in my collection, but it is impossible to know whether it would have grown up in any way distinct from the type in form, and the red colour of the nacre has no value as a specific distinction.

There are however two, if not three, distinct varieties.

Var. OBLIQUA, nov. (Pl. **18**. fig. 11.)

Diagnosis.—Jickeli (Nova Acta Akad. d. Naturf. vol. xxxvii. 1874, p. 274) mentions two shells found by Prof. Schweinfurth in the Bahr al-Ghazâl which he does not name. They are described as having the dorsal margin much higher posteriorly and lower anteriorly. Thus the shells have an oblique appearance. Also the dorsal margin is more or less angular at the anterior end.

Locality.—I took this variety at Tawîla (two separate valves), Masran Island (three), Melût (six). There are also two specimens from this last locality intermediate between the variety and the type in shape.

Dimensions.—The dimensions given by Jickeli are, long. 30, alt. 17·75, crass. 11·5 mm.

One example from Melût is near this, while another is still larger, measuring long. 39·5, alt. at umbo 19, greatest alt. 24, crass. 16 mm.

Var. ELONGATA, nov. (Pl. **18**. figs. 9, 10.)

Diagnosis.—Shell more elongated, having the umbo nearer the anterior end. The adult has the test thicker and more swollen and the teeth are generally very strong and jagged.

The two valves from Tawîla, which I have referred to the last variety, resemble this in their great strength but are oblique in form.

Locality and Dimensions.—The variety *elongata* occurred at Ad-Duwêm (two), Tawîla (three), and Gebel Ahmad Aghâ (one). The last measures, long. 42, alt. at umbo 21, greatest alt. 23·5, crass. 20 mm. The largest from Tawîla measures, long. 40·5, alt. at umbo 21·5, greatest alt. 23·5, crass. 18 mm.

A small specimen found at Mogran and another at Khor Surkab near Kerreri are shorter than usual and much swollen, also the posterior dorsal margin is lower. The former measures, long. 31·5, alt. at umbo 19, greatest alt. 19·5, crass. 15·5 mm.

Two individuals from Ad-Duwêm have the test much thinner, the teeth less strong, and the exterior a brighter green than usual; the nacre is bluish white.

Nodularia (Cælatura) sobaënsis, sp. nov.

Five specimens were taken at Sôba on the Blue Nile.

A description of the species by Mr. H. Preston will be found in Appendix I., p. 266.

Section **Lanceolaria**, *Conrad*.

Nodularia (Lanceolaria) teretiuscula, *Philippi*.

Unio teretiusculus, Philippi, 1847, 'Abbildg. Beschreib.' vol. iii. p. 45, pl. 3. fig. 3.
Unio cailliaudi, Férussac, von Martens, 1866, Malak. Blätt. p. 13.
Unio lithophagus, Parreyss in MS.
Unio lithophagus, Ziegler in MS.

Only a left valve was found at Tawîla on Abba Island. It agrees in form with the holotype, but is smaller. It measures, long. 39·5, alt. 17 mm.

The holotype is also from the White Nile, and measures, long. 51, alt. 21, crass. 19 mm.

This species has had the names *cailliaudi* and *lithophagus* bestowed upon it, which have apparently only existed in manuscript, for they had not been published previous to Philippi's description. Von Martens gives the name *cailliaudi* priority, though there is no certain evidence of Férussac having published it. Philippi credits the name *lithophagus* to Parreyss, while von Martens refers it to Ziegler. *N. teretiuscula* is also recorded from the Bahr el-Ghazâl, Albert Nyanza, Nubia, and Egypt. I have seen the specimen in the British Museum (Nat. Hist.) from Abu Zeit referred by Captain Flower to this species, and find it belongs to the following variety.

Var. pallaryi, nom. nov. (Pl. **18**. figs. 12–14.)

Var. *lithophaga*, Ziegler, Pallary, 1902, Bull. Inst. Égypt. ser. iv. no. 3, p. 95.

Diagnosis.—This variety differs from the type in being lower, more elongated, and more pointed posteriorly, in the umbo being nearer the anterior end, and in the anterior lateral teeth of the left valve being nearer together. The valves are also much swollen. The exterior is dark brown, the nacre bluish white, tinged with salmon-pink inside the umbo, and in one example from Ad-Duwêm this colour has spread all over the interior.

M. Pallary is mistaken in referring this form to *Unio lithophagus*, Ziegler, which is a synonym in manuscript of the typical name, and according to von Martens (Malak. Blätt. 1866, p. 13) has similar dimensions. I therefore propose calling it after M. Pallary.

According to my experience the variety is much more abundant than the

type in the Bahr al-Abyad. It was found at Mogran (fifteen), Ad-Duwêm (seventeen), on Abba Island, both opposite Fachi Shoya (three), and at Tawîla (thirteen), Kosti (two), Hillet Abbâs (five, and five separate valves), Masran Island (one), Gebel Én (six), north of Gebel Ahmad Aghâ (two very small), south of Melût (three), Lûl (one), Taufikîyâ (one valve). Total sixty-eight. Reported also from the White Nile by M. Pallary. My largest specimen occurred a little to the south of Melût; it measures, long. 44, alt. 17·5, crass. 16·5 mm.

Genus MUTELA, *Scopoli*.

MUTELA NILOTICA, *Sow.*

Iridina nilotica, Sowerby, 1824, Zool. Journ. vol. i. p. 53, pl. 2. fig. 1.
Iridina nilotica, Cailliaud, 1827, 'Voyage à Méroë,' vol. iv. descr. p. 262; 1823, Atlas, vol. ii. pl. 60. fig. 11.

A single valve of a specimen of this species was found by Dr. Longstaff near Gordon's Tree, Khartûm. It is not so large as Sowerby's type, but agrees with it in form, the dorsal and ventral margins being nearly parallel. It measures, long. 96, alt. at umbo 32, alt. post. 36 mm. Sowerby states that his specimen was given to him by M. Cailliaud, and that it came from Sennaar. A shell in the British Museum (Nat. Hist.) is probably the holotype; it agrees with the figure in shape, and has the adventitious marks in the nacre, which are represented in the drawing, only *reversed* as would be the case if they were copied from the reflection in a mirror. There is no certain record of the locality of this individual. It measures, long. 144, alt. 54 mm.

The name *nilotica* appears to have been given by Férussac in MS., but Sowerby was the first to describe it, though the shell had been previously figured by Cailliaud.

This species greatly resembles the West African form, *M. exotica*, Lam. (*elongata*, Sow.), but it is distinguished by only having traces of crenulations along the hinge-line, while they are very strongly developed in *M. exotica*.

Cailliaud's figured specimen came from Joseph's Canal, Lower Egypt. The species also occurs in Upper Egypt, the Blue and White Niles, and Albert Nyanza.

Var. ANGUSTATA, *Sowerby*, sp.

Iridina angustata, Sowerby, 1868, in Reeve's 'Conch. Icon.' vol. xvi. pl. 2. figs. 4 & 5.
Iridina nilotica, Savigny, 1813, 'Descr. Égypte,' pl. 7. fig. 2.
Iridina nilotica, Audouin, 1826, 'Explic. Somm. Planches Moll. Égypte,' p. 46.

Twenty specimens were taken: near Mogran (seven), at Tawila (one), Gebel Én (one), Gebel Ahmad Aghâ (four), Masran Island (five), and a single valve, south of Melût (two). This form shows a certain amount of variation. The shells found near Mogran come nearest to the holotype of

M. nilotica in having less difference between the height of the anterior and posterior ends, the posterior dorsal margin being less produced, the posterior ridge is also very distinct. The mature specimens from Gebel Ahmad Aghâ, on the other hand, have the posterior dorsal margin greatly produced, and the valves are very ventricose, so that the posterior ridge is not so sharp; also the ventral margin is more sinuated. Several individuals show faint taxodont teeth on the hinge. The exterior is dull green, the nacre greyish pink.

An individual from Mogran measures, long. 119, alt. at umbo 41, alt. post. 50, crass. 26 mm.

The largest, taken a little north of Gebel Ahmad Aghâ, measures, long. 130, alt. at umbo 44, alt. post. 56, crass. 36 mm.

This form was first described by Sowerby in Reeve, but it had previously been figured by Savigny, and was referred to *Iridina nilotica*, Fér. MS. by Audouin, who wrote the explanation of Savigny's plates. Sowerby names fig. 4 on Pl. 2. *op. cit. I. nilotica*, but it is really the same form as fig. 5, which he calls *angustata*, differing only in age. It appears more advisable to regard *M. angustata* as a variety of *M. nilotica* rather than a distinct species, the chief difference being a greater expansion of the posterior dorsal margin in the former.

Sowerby merely gives "Africa?" as locality. There are specimens in the British Museum (Nat. Hist.) marked "Egypt and Senegal," also "River Nile."

It is reported from Egypt, the Blue Nile, Lake Tchad, and West Africa.

Genus Mutelina, *Bourguignat.*

Mutelina rostrata, *Rang.*

Iridina rostrata, Rang, 1835, 'Nouv. Archiv. Muséum,' p. 316.

Eighty-three specimens were taken at the following places: near Mogran (thirty-five), Ad-Duwêm (eighteen), Tawîla (five), south of Melût (six), and at Lake Shâmbê (nineteen).

The largest were met with at the latter place, and five of the shells found there have the posterior dorsal margin rather higher than usual. The biggest measures, alt. 35, long. 100 mm.

Many of the younger shells have the epidermis of a beautiful iridescent green colour.

This species was found by Captain Flower south of Abu Zeit on the White Nile, but it is not recorded from this region by M. Pallary, Herr Hägg, or Herren Boettger and Haas. It occurs in Egypt, and has been reported from Lake Tchad (*Germain*), as well as from Senegal (*Jousseaume*).

Genus Pseudomutela, *Simpson*.

Pseudomutela plicata, *von Martens*.

Mutela plicata, von Martens, 1866, Malak. Blätt. p. 10.

A single specimen was taken at Gebel Ahmad Aghâ. Since only two examples appear to have been recorded previously, this is an interesting find. These are in the British Museum (Nat. Hist.); one is figured by Sowerby in 'Conch. Icon.' vol. xvi. 1868, pl. 2. fig. 3, and both are referred to by Jickeli, p. 270. The locality in the British Museum register is "Cataract at Syene," Jickeli gives Sennaar (Kotschy), and Sowerby gives no locality. Gebel Ahmad Aghâ is about one degree south of the province Sennaar; the town of this name, however, is on the Blue Nile, lat. 13° 25′ N. My specimen measures, long. 87, greatest alt. 31·5, alt. at umbo 23, crass. 17 mm., and is intermediate in size between the two in the British Museum, the largest of which measures, long. 106, greatest alt. 36, alt. at umbo 27·5, crass. 20 mm. These latter are named *Iridina plicata*, Parreyss. In the Collection Morelet, 'Voy. Welwitsch,' 1868, p. 40, the species is attributed to Parreyss, but there is no description. Von Martens (Malak. Blätt. 1866, p. 10) mentions a specimen in the British Museum, and gives a diagnosis: though this is very brief, the species must be credited to him as the first really to describe it. Sowerby in 1868 describes it more fully, calling it *Mycetopus plicatus*, and referring it to Gray in MS.

P. plicata somewhat resembles *Mutelina rostrata*, but is distinguished by being subquadrate posteriorly, and gaping at both ends, by having a rather wide groove running from the umbo to the posterior end, and a larger cardinal tooth in the right valve. The shells in the British Museum are yellowish externally, while mine is darker, being greyish green, with the nacre salmon-pink, merging into bluish white at the margin.

Genus Spatha, *Lea*.

Spatha rubens, *Lam*.

Anodonta rubens, Lamarck, 1819, Hist. Nat. Anim. sans Vert. vol. vi. pt. 1, p. 85.
Spatha caillianudi, von Martens, 1866, Malak. Blätt. vol. xiii. p. 9.

An adult specimen measuring long. 112, alt. 73, crass. 42 mm., as well as the right valve of a still larger example measuring long. 145, alt. 97 mm., were obtained from a fishing boat at Kosti. Immature shells in different stages of growth were taken at Ad-Duwêm, Tawîla, and Lake Shâmbê.

Von Martens considered this Nile species of *Spatha* distinct from that described by Lamarck from West Africa, and therefore called it *S. caillianudi*. I have, however, compared my specimens from the White Nile, and also some I obtained from a pond at Shabra Maut, near Gizeh, with examples rom West Africa in the British Museum (Nat. Hist.), and I consider them

conspecific, for there is no greater variation in form and colour than occurs in a large series from one district, such as I possess from Shabra Maut. The nacre is generally deep pink; my entire specimen from Kosti is pale in tone, and two shells M. Pallary has given me from Cairo and the Canal Mahmoudich are respectively pearly white and white tinged with pink. M. Pallary (Mém. Inst. Égypt. vol. vi. fasc. 1, 1909, pp. 83, 84) has shown that the forms regarded as distinct species under the names *lepsii*, Jickeli, *canaida*, Bourg., *arcuata*, Caill., and *letourneuxi*, Bourg., are merely stages in the growth of *S. rubens*. I not only have examples from the White Nile in these different stages, but also shells from Shabra Maut indicating them clearly by the lines of growth.

This species has previously been recorded from the White Nile, the Blue Nile, the Bahr el-Ghazâl, Abyssinia, Uganda, Lake Tchad, and its occurrence in Egypt and also in West Africa has just been mentioned.

The figure of *S. wissmanni* given by von Martens in 'Conch. Mittheil.' vol. iii. 1889, pp. 9, 10, is hardly distinguishable from an old example of this species. It is from the Rivers Lubi and Lubilasch, tributaries of the Congo, in S. lat. 5° 6′.

Spatha innesi, *Pallary*.

Spatha innesi, Pallary, 1902, 'Moll. recueillis Innes Bey,' Bull. Inst. Égypt. ser. iv. no. 3, p. 97, pl. 2. fig. 2.

Specimens were taken near Mogran, at Ad-Duwêm, Tawîla, Kosti, Gebel Ahmad Aghâ, near Melût, at Kôdôk, and in Lake Shâmbê. They were most numerous at Ad-Duwêm, where twelve examples were found in different stages of growth.

The holotype measures, long. 60, alt. 37, crass. 25 mm. My biggest shell exceeds this, measuring, long. 72, alt. 42·5, crass. 28·5 mm. It is from Ad-Duwêm. The specimens vary in shape, some having the ventral sinuation more pronounced, some are more elongated, while others have the test considerably thicker. A small example from Melût is remarkably solid, more oblong in form, with the posterior dorsal margin higher.

This species bears some resemblance to the western form, *S. chaiziana*, Rang, with specimens of which I have compared it, but I fully agree with M. Pallary in considering it distinct.

The exact locality of the holotype is not given, but since Dr. Innes Bey kindly gave me an example from Kâkâ, it may also be from the same habitat.

Spatha wahlbergi, *Krauss*.

Iridina wahlbergi, Krauss, 1848, Südafrik. Moll[1] p. 19, pl. 2. fig. 1.
Spatha hartmanni, von Martens, 1866, Malak. Blätt. vol. xiii. p. 10.

Four entire specimens were taken near Mogran, and a single valve at

Ad-Duwêm. None are mature. They agree with the figures of both Krauss and Jickeli, but are not so large. I compared them with two specimens in the British Museum (Nat. Hist.) found in the White Nile by Captain Flower, and also with some from Natal. They are similar in shape and muscular markings to all of these, but are not so large as the former; my largest, however, is nearly the same size as the smallest from Natal. They differ in the colour of the nacre, mine being bluish or greenish white, and the others pink. Krauss says the inner surface of his shell is white, the middle flesh-colour, while the margin is green and reddish iridescent. Much stress cannot be laid on the tint of the nacre, as it is known to vary greatly in many freshwater bivalves.

My largest example from Mogran measures, long. 68·5, alt. 34, crass. 18·5 mm. Krauss's specimen measures, long. 113, alt. 52 mm. Flower's specimen measures, long. 112, alt. 55 mm. The largest from Natal measures, long. 70, alt. 37 mm.

It is interesting to note what a wide range this species has. The type of *S. wahlbergi* is from the Apies River, the most southern source of the Limpopo River. The species has been reported from several other localities in South, East, Central, and West Africa; amongst them may be mentioned Khartûm, Sennaar, between Ad-Duwêm and Goz Abu-Goma (*Hägg*), Bahr el-Zarâfa (*Rohl*), and Lake Tchad.

SPATHA MARNOI, *Jickeli*.

Spatha marnoi, Jickeli, 1874, 'Fauna N.O.-Afrikas,' p. 264, pl. 8. fig. 3.

The right valve of a specimen of this species was found on Abba Island opposite Fachi Shoya. It measures, long. 106, alt. 52 mm. Two smaller dead and worn examples were taken in recently dredged mud a short distance up the Bahr el-Zarâfa. This latter locality is the habitat of the holotype, whose long. equals 85, alt. 40·75 mm.

SPATHA FOURTAUI, *Pallary*.

Spathella fourtaui, Pallary, 1902, Bull. Inst. Égypt. ser. iv. no. 3, p. 96, pl. 1. fig. 3.

Twenty-seven specimens were taken at the following localities: Tawîla, Masran Island, near Gebel Ahmad Aghâ, south of Melût, Taufikîyâ, Hillet al-Nûwêr, and fragments of a fair-sized specimen at the southern entrance to the Bahr el-Zarâfa. They were most abundant to the south of Melût, where nineteen examples were found. The largest is from Hillet al-Nûwêr; it measures, long. 63, alt. 29·5, crass. 17 mm.; it is slightly lower than usual. A single valve from Melût measures, long. 60, alt. 29 mm.

This species greatly resembles *S. marnoi* and may possibly be a variety of that species. It shows a certain amount of variation, and some specimens are very like the small examples of *S. marnoi* from the Bahr el-Zarâfa in form

and size, but not in colour. *S. fourtaui* is distinguished from *S. marnoi* in being smaller, thinner, having the posterior dorsal margin slightly more angular, the ventral margin more sinuated, and in the nacre being bluish or greenish white instead of pink.

M. Pallary does not state the exact locality on the White Nile where the holotype was found.

Family Cyrenidæ.

Genus Corbicula, *Megerle von Mühlfeldt.*

Corbicula consobrina, *Cailliaud.*

Cyrena consobrina, Cailliaud, 1823, 'Voy. à Méroë,' vol. ii. pl. 61. figs. 10 & 11; 1837, vol. iv. p. 263.

This species occurred almost throughout the whole length of the river we traversed. I took it near Mogran, at Ad-Duwêm, Kosti, Abba Island, Hillet Abbâs, Gebel Én, Mashra Zarâfa Wood Station, Kâkâ, Hillet al-Nûwêr, Lake Shâmbê, south end of the Bahr el-Zarâfa, and Gondokoro. It was very numerous near Mogran and in Lake Shâmbê. Most of the specimens, however, are immature; the largest is a single valve from Hillet Abbâs which measures, long. 34, alt. 30 mm. Another from Mogran measures, long. 23, alt. 20·5, crass. 14·5 mm. The colour varies from light green in young to darker green, brown or nearly black in adult examples. *C. consobrina* exists throughout the region of the Nile and in Abyssinia.

Corbicula artini, *Pallary.*

Corbicula artini, Pallary, 1902, 'Moll. recueillis par le Dr. Innes Bey dans le Haut Nil,' Bull. Inst. Égypt. ser. iv. no. 3, p. 93, pl. 1. fig. 4.

Corbicula lavigeriana (Bourguignat), Germain, 1906, Bull. Mus. Hist. Nat. Paris, p. 583, fig. 18 *b*.

Only found in the Bahr al-Abyad, where it occurred at the following places: near Mogran, at Ad-Duwêm, Abba Island, Kosti, Hillet Abbâs, Masran Island, and Gebel Én. It was most numerous at this latter place; a single valve taken there is the largest example, measuring, long. 23, alt. 24 mm. A specimen from Tawîla on Abba Island measures, long. 21, alt. 21, crass. 15·5 mm. M. Pallary gives the dimensions as long. 22, alt. 23, crass. 18 mm. This is a remarkably solid shell; the exterior varies from pale green when young to dark rich brown when adult, the interior is purple. M. Pallary states that this species is rarer at Alexandria and Ismaîlia than in the White Nile.

Genus Sphærium, *Scopoli*.

Sphærium teilhardi, *Pallary*.

Sphærium teilhardi, Pallary, 1909, Mém. Inst. Égypt. vol. vi. fasc. i. p. 74, pl. 4. fig. 27.

About thirty-four specimens were taken. The species was determined by M. Pallary, who had recorded it from Lower Egypt, but this seems to be the first notice of its occurrence in the Sûdân. It was found both to the north and south of Lake No, at Abba Island, Hillet Abbâs, Gebel Én, Lake Shâmbê, and possibly one immature shell from Gondokoro is referable to this species. The largest is from near Gebel Én; it measures, long. 11·5, alt. 8·5, crass. 5·5 mm.

? Pisidium sp.

Only two small specimens possibly referable to this genus were found, one at Gebel Én and the other at Lake Shâmbê. They are, however, too immature for certain identification.

Genus Eupera, *Bourguignat*.

Eupera parasitica, *Desh*.

Pisum parasiticum, Parreyss in Deshayes, 1853, 'Catal. Conch. Bivalv. Brit. Mus.' vol. i. p. 280.

Limosina ferruginea, Jickeli, 1874, 'Fauna N.O.-Afrikas,' p. 293, pl. 11. fig. 16.

Five specimens were taken, four at Gebel Én and one at Hillet al-Nûwêr. M. Pallary kindly examined this and the two following species. He states that it occurs throughout the whole course of the Nile; Bourguignat records it from Abyssinia and von Martens from the Victoria Nyanza.

Eupera jickeli, *Bourg*.

Eupera jickeli, Bourguignat, 1883, 'Hist. Malac. Abyssinie,' p. 134.

Limosina ferruginea, Jickeli, 1874, op. cit. p. 293, pl. xi. fig. 17.

Nine examples in Lake Shâmbê, and thirteen from Masran Island. Only one specimen was found by Dr. Innes Bey in the White Nile, and the exact locality is not stated. Bourguignat records it from Abyssinia and throughout the course of the Nile to Lower Egypt.

Eupera letourneuxi, *Bourg*.

Eupera letourneuxi, Bourguignat, 1883, 'Hist. Malac. Abyssinie,' p. 134.

Seven specimens were found near Gebel Ahmad Aghâ in the interstices of clusters of *Ætheria elliptica*, Lam. Bourguignat only reports its occurrence in the canals of Alexandria. This appears to be a new record for the White Nile.

List of Localities with their distances from Khartûm and their latitude N.

Miles by river from Khartûm.		Latitude North.
12	Kerreri	15° 47′
	Khartûm	15° 37′
14	Sôba (Blue Nile)	15° 32′
125	Ad-Duwêm	14° 0′
213	Sennaar (Blue Nile)	13° 25′
	Abba Island	13° 22′
	Tawîla	13° 16′
192	Kosti	13° 10′
	Hillet Abbâs	13° 7′
209	Masran Island	12° 45′
238	Gebel Én	12° 37′
	Renk	11° 45′
353	Gebel Ahmad Aghâ	11° 0′
	Mashra Zarâfa	10° 50′
404	Kâkâ	10° 40′
413	Melût	10° 27′
459	Kôdôk (Fâshôda)	9° 54′
511	Lûl	9° 47′
	Wâw	9° 40′
518	Taufikîyâ	9° 25′
	Dûlêb (R. Sobat)	9° 22′
612	Lake No	9° 30′
	Bahr el-Zarâfa	9° 25′–7° 0′
751	Hillet al-Nûwêr	8° 13′
865	Lake Shâmbê	7° 0′
916	Kanîsa	6° 50′
	Malek	6° 7′
	Sheik Tombê	5° 43′
1072	Kîrô	5° 22′
1086	Mongalla	5° 12′
	Lâdô Wooding Station	5° 8′
1107	Lâdô	5° 2′
1116	Gondokoro	4° 54′
	Rejâf Wooding Station	4° 50′
1128	Rejâf	4° 45′

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APPENDIX I.

Description of New Species. By Hugh B. Preston, F.Z.S.

Segmentina kanisaënsis, *Preston*, sp. nov. (Pl. 18. figs. 17–19.)

Shell small, suborbicular, with concave spire, reddish brown; whorls 4, regularly increasing, the first three sunken, the last carinate below, marked with oblique growth ridges, and sculptured with microscopic, wavy spiral striæ; suture well impressed; base of shell flat, slightly polished, sculptured as above; umbilicus rather shallow, wide, about one-fourth the diameter of the shell; columella margin very short and obliquely descending, diffused above into a not very well defined parietal callus, which reaches to the upper margin of the labrum; labrum acute, receding below, projecting above; aperture bluntly sagittiform.

Alt. 1, diam. maj. 4, diam. min. 3·25 mm. Aperture: alt. 0·75, diam. 1 mm.

Hab. Kanisa; five specimens (*Mrs. G. B. Longstaff*).

This would seem to be the shell cited as *S. angusta*, Jick.* by Pallary in his paper entitled "Mollusques recueillis par le Dr. Innes Bey dans le Haut Nil" †, from which it differs chiefly in its less polished appearance, flatter, more angular and broader form, more convex and less tightly coiled earlier whorls, less concave spire, flatter base, and wider umbilicus.

Streptaxis sudanica, *Preston*, sp. nov. (Pl. 18. figs. 15, 16.)

Shell perforate, ovately rectangular, whitish, thin, shining; whorls 6, the first very small, the second proportionately large, the third and fourth regularly increasing, the fifth and sixth rapidly increasing and eccentric; the apical whorls smooth, polished, the remainder sculptured with oblique, arcuate, rather closely set, transverse costulæ, which become finer on the

* Jickeli, 1874, 'Fauna Land- u. Süsswasser Moll. N.O.-Afrikas,' pp. 220–221.
† Le Caire, Bull. Inst. Égypt., sér. iv. 1902, p. 90.

last whorl; suture impressed, crenellated by the terminations of the transverse costulæ; umbilicus narrow, deep, somewhat ovate; columella descending in a curve, outwardly expanded, diffused above into a somewhat ill-defined, outwardly spreading, parietal callus which reaches to the upper margin of the labrum; labrum outwardly expanded and reflexed, projecting in front, receding below, and a little above to form a broad and shallow sinus; aperture ovate.

Alt. 16·25, diam. maj. 11, diam. min. 9·5 mm. Aperture: alt. 8, diam. 5·5 mm.

Hab. Sheik Tombê; one young and two adult specimens (*Mrs. G. B. Longstaff*).

Nodularia (Cælatura) sobaënsis, sp. nov. (Pl. 18. figs. 1–3.)

Shell rather small, ovate, covered with a somewhat thin, brownish-olive periostracum which becomes scabrous posteriorly, painted (with the exception of the extreme anterior and posterior sides) with fine, radiate, greenish, transverse bands; both valves marked with concentric lines of growth, considerably wrinkled and coarsely nodulated towards the umbonal regions; dorsal margin sloping upwards in a straight line from the anterior to the posterior side; ventral margin gently rounded; anterior side somewhat angularly rounded; posterior side broad, obtuse, rounded below; right valve bearing a somewhat elongate, erect cardinal, a very fine and rather short anterior, and an elongate, slightly curved posterior lateral; left valve bearing a weak, rather minutely nodulous cardinal, and two elongate, curved, posterior laterals; both anterior and posterior muscular scars well impressed, the anterior especially so; pallial line well marked and continuous in both valves; interior of shell pale pinkish.

Long. 19, lat. 31, diam. 12 mm.

Hab. Sôba, Blue Nile; five specimens (*Mrs. G. B. Longstaff*).

The specimens from which the present species is described have been submitted to M. Paul Pallary, who is also of opinion that they cannot be referred to any hitherto known form.

APPENDIX II.

The Dentition &c. of Veronicella nilotica, *Cockerell.* (Text-figs. 1 & 2.)

By G. C. Robson, B.A.

(By permission of the Trustees of the British Museum.)

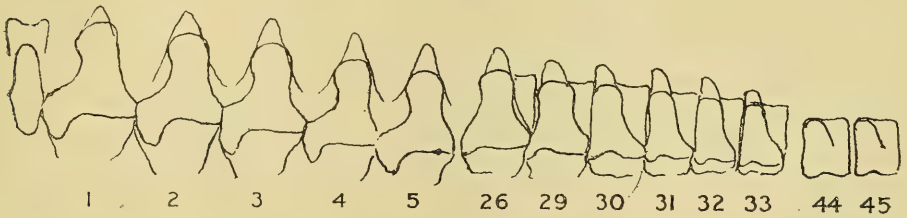
A single example of this species was obtained by Mrs. G. B. Longstaff at Hillet al-Nûwêr, an islet on the Bahr el-Gebel. It was found among papyrus on the river bank; and although smaller than the type, it corresponds very closely to the description given by Prof. Cockerell ('Nautilus,' xxiii. p. 108). The author did not give any account of the radula or jaw in this

description, nor has any been subsequently published. In addition, Prof. Cockerell apparently was not in possession of any information as to the actual colour of the species, his account being based on the colour of a specimen preserved in alcohol. Thanks to the careful notes of the colour made by Mrs. Longstaff, and to the kindness of Dr. H. M. Gwatkin, who lent the author the radula of the type specimen for purposes of comparison with that of Mrs. Longstaff's example, it is now possible to give a fuller account of this interesting species which, as Prof. Cockerell says, extends the range of the genus fifteen degrees further north in E. Africa.

Veronicella nilotica, *Cockerell.*

External appearance and remarks on general disposition of some of the internal organs, see 'Nautilus,' xxiii. p. 108.

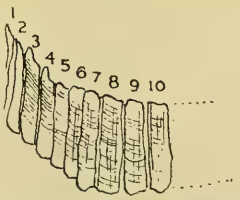
Fig. 1.



Veronicella nilotica, Cockerell.—Radula. Holotype in possession of the Rev. Dr. Gwatkin. By Nile above Khartûm. Figured under 4 oc. × 6 obj., Reichert.

Radula.—The exact number of teeth in a row is not quite certain but is probably not more than 50; 48 may possibly be the average number in a row. The sinuosity indicated on the base of the teeth numbered 29–33 in the figure is frequently, though not always, emphasized so as to form a

Fig. 2.



Veronicella nilotica, Cockerell.—Jaw. Holotype in Zoological Dept. British Museum. Hillet al-Nûwêr, Bahr el-Gebel. Figured under 4 oc. × 3 obj., Reichert.

marked notch or indentation. Somewhere about the twenty-ninth or thirtieth tooth in each row, a marked transition is effected toward the

square marginal type, though a modification of the lateral is appreciable earlier in the series.

Jaw.—Only one side of the jaw is figured. The complete jaw is composed of a total of 19 rather narrow plates set close together. The width of these plates varies but their disposition is not bilaterally symmetrical, there being one broad plate on one side and three on the other.

Colour.—Dorsum very dark grey, hyponotum dirty yellow turning to deeper yellow anteriorly. Covered generally with small black spots. Foot sole orange. Tentacles dark grey.

[The Collection has been presented to the British Museum (Natural History).]

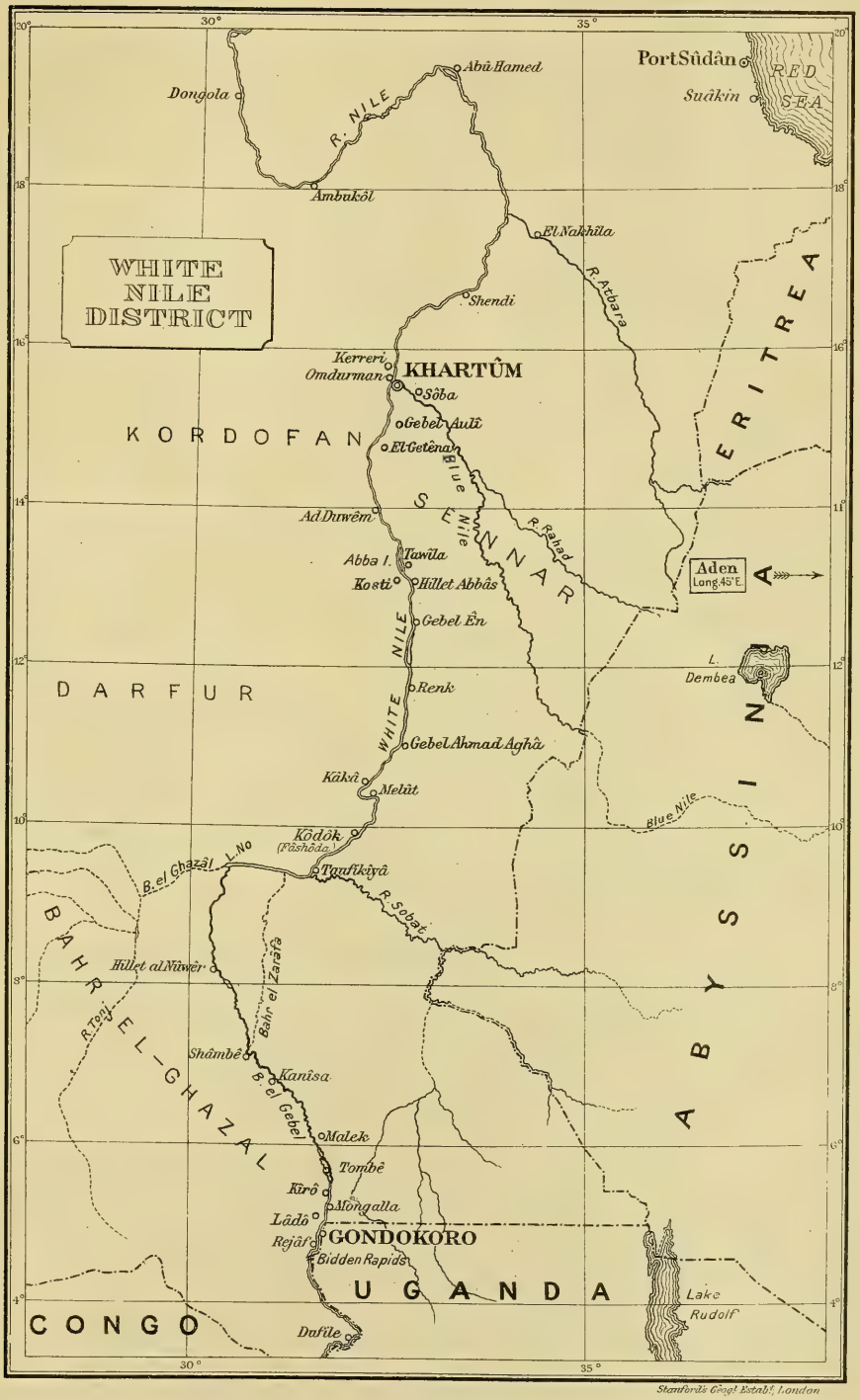
EXPLANATION OF PLATES 17 & 18.

Plate 17.

Map showing localities of Mollusca.

Plate 18.

Fig. 1. *Nodularia* (*Cælatura*) *sabaënsis*, Preston, sp. nov. External aspect of right valve.
2. „ „ „ Internal aspect, showing hinge.
3. „ „ „ Dorsal aspect. Nat. size.—Sôba, Blue Nile.
4. „ „ *ægyptiaca*, Caill., var. *shambiensis*, Longstaff, var. nov. External aspect of right valve.
5. „ „ „ Internal aspect of thin shell showing hinge.
6. „ „ „ Internal aspect of thick shell showing strong teeth.
7. „ „ „ Dorsal aspect. Nat. size.—Lake Shâmbê, Bahr el-Gebel.
8. „ „ *parreyssi*, Phil. Internal aspect of shell similar to Philippi's figure of type showing hinge.—Ad Duwêm.
9. „ „ „ var. *elongata*, Longstaff, var. nov. External aspect of right valve.
10. „ „ „ var. *elongata*, Longstaff, var. nov. Dorsal aspect. Nat. size.—Gebel Ahmad Aghâ.
11. „ „ „ var. *obliqua*, Longstaff, var. nov. External aspect of right valve. Nat. size.—S. of Melût.
12. *Nodularia* (*Lanceolaria*) *teretiuscula*, Phil., var. *pallaryi*, Longstaff, var. nov. External aspect of right valve.
13. „ „ „ Internal aspect showing hinge.
14. „ „ „ Dorsal aspect. Nat. size.—Near Mogran.
15. *Streptaxis sudanica*, Preston, sp. nov. Front aspect.
16. „ „ Dorsal aspect. Nat. size.—Sheik Tombê.
17. *Segmentina kanisaënsis*, Preston, sp. nov. Front aspect.
18. „ „ Spiral aspect.
19. „ „ Basal aspect.—Kanîsa.



MAP SHOWING LOCALITIES OF MOLLUSCA



Grout sc. & imp.

MOLLUSCA FROM WHITE NILE.

Spolia Runiana.—II. *Funiculina quadrangularis* (Pallas); *Diazona violacea*, Sav.; *Forbesella tessellata* (Forbes); variation in *Ascidia*; and records of various rare Invertebrata.

By W. A. Herdman, F.R.S., F.L.S., Professor of Zoology in the University of Liverpool.

(Plate 19.)

[Read 6th November, 1913.]

In Part I. of "Spolia Runiana," last year *, I dealt mainly with Hebridean specimens of the giant Pennatulid, *Funiculina quadrangularis*, and of the Compound Ascidian *Diazona violacea*. During the cruise of the yacht 'Runa' in the present summer (July and August 1913), we were fortunate enough to capture many additional specimens of both these comparatively rare animals, and this wealth of material has enabled me to add some further particulars to what was previously recorded. During the cruise I paid particular attention to the Tunicata, and preserved large numbers of several common species with a view to studying individual variations and their bearing on specific characteristics. We obtained also some specimens of the less common Cynthiid *Forbesella tessellata* (Forb.), and the examination of these has enabled me to offer some remarks upon the position of this isolated species in the "system" of classification.

The occurrence of a few other rare forms seems worth putting on record :—

I. New or Interesting Records.

(1) The Starfish *Pteraster militaris* (O. F. Müll.) was dredged in the Inner Sound, between the Island of Raasay and the mouth of the Gair Loch (Ross-shire), from a depth of 20 fathoms, on August 18th. This is a northern species, found on the coast of Norway, and not previously known, I believe, from the British seas — the nearest locality being the Faröe Channel, 'Porcupine' expedition, from over 400 fathoms; and, again, the 'Triton' expedition, 530 fathoms.

Prof. Jeffrey Bell in a letter (Oct. 22nd) remarks : "I do not suppose it occurs in strictly British waters." Consequently the present record makes an addition to the known British Fauna.

Our Scottish specimen measures as follows :—

R = 22 mm. r = 8 mm.
Greatest height = 8 mm.
Breadth of arm at base = 10 mm.

A red eye-spot is conspicuous at the extremity of each arm.

* Journ. Linn. Soc., Zool. vol. xxxii. p. 163, May 1913.

(2) The Echinid *Echinus acutus*, Lamk., was dredged in the Sound of Mull, north of the Green Islands, from a depth of 20–30 fathoms on July 16th, 1913.

This is a southern form which occurs in the Atlantic to the west and south of Ireland, and has apparently not been recorded previously from Hebridean waters.

The dimensions of our specimen are :—

Diameter of test = 54 mm.
Height = 36·5 mm.
Diameter of peristome = 17·5 mm.
Diameter of periproct = 6·5 mm.
Largest spine = 26 mm.

The bases of the spines are of a greenish colour. The conspicuous characters of this Echinid when alive—which at once attracted my attention to it in the dredge—were the comparatively few but very long spines, and the general white coloration.

(3) Amongst other more noteworthy Echinoderms obtained were :—

Antedon tenella (Retzius), as well as *A. phalangium* (G. Müll.) and *A. bifida* (Penn.).
Asterias muelleri (Sars), as well as *A. rubens*.
Ophiocnida brachiata (Mont.), with other commoner Ophiuroids.
Phyllophorus pellucidus (Düb. & Kor.).

Mr. H. C. Chadwick, who has examined these Echinodermata for me, throws doubt upon the distinctness of the last species from *P. drummondi* ; and he is inclined not to recognise the validity of the characters drawn from the spicules known as "tables" in the integument of *P. pellucidus* and of *P. drummondi*.

(4) Several boulders brought up (with much labour, and risk to the dredging-gear) from some of our deeper hauls, on rough bottoms, yielded a few examples of the rare solitary corals :—

(?) *Paracyathus taxilianus*, Gosse ; the Minch, 30 fathoms—a doubtful species.
Caryophyllia smithii, Stokes ; off Ardnamurchan, 22 fathoms ; and south of the Island of Eigg, 30 fathoms.

We also got the following other noteworthy Actinozoa :—

Epizoanthus incrustans (Düb. & Kor.), off Vaternish Pt., Skye, 50 fathoms ; and *E. couchii* (Johnst.), Loch Hourn, 35 fathoms.

Sarcodictyon catenata, Forbes, at many localities, and of three quite distinct colours, viz. :—(1) the usual deep red, (2) pale yellow or creamy white, and (3) a bright cinnamon tint, exactly as figured by Forbes and Goodsir * in 1851 from the specimen dredged off the Croulin Islands, and which they

* Trans. Roy. Soc. Edin. vol. xx. p. 307.

described as a new species under the name *S. agglomerata*. We dredged some specimens of the last from the original locality, but I have no doubt they are simply a colour variety of *S. catenata*.

(5) Professor Dendy, who has kindly looked over the sponges of the 'Runa' collection, notes the following as the more interesting forms, all from the Shiant East Bank and neighbouring parts of the Minch :— *Tethya lyncurium*, *Ficulina ficus*, *Suberites carnosus*, *Dictyocylindrus stuposus*, *Phakellia ventilabrum*, *Ph.* (*Isodictya*) *infundibuliformis*, and a series of *Quasillina* (*Polymastia*) *brevis* and *Polymastia mammillaris*, which Prof. Dendy says "seems to indicate that Bowerbank was right in assigning the species, *Q. brevis*, to the genus *Polymastia*; but the question wants working out with specially preserved material."

Amongst the other, commoner, sponges obtained were many specimens of the large white *Esperella lingua*, and every specimen examined had embedded deeply in its interior some examples of the eggs or embryos of the cuttle-fish, *Rossia macrosoma*. I had found these in the same position under the same circumstances the previous summer, and, now again in 1913, I found sometimes quite young eggs and sometimes far advanced embryos, with the eyes and the arms and other parts of the cuttle-fish distinctly visible on removing the opaque egg-shell. This year, however, on opening some of these eggs, I found no cuttle-fish embryo, but the whole of the interior of what had evidently been the covering of the cuttle-fish egg filled up with sponge-tissue like that outside. The only explanation I can suggest is that some of the eggs or embryos die, or are unable to break out through the sponge to the exterior, and that in these cases the neighbouring tissue grows into the capsule and replaces the normal contents.

(6) Mr. A. O. Walker, who was with us on the 'Runa' for a few days in the earlier part of the cruise collecting Amphipods, and who has kindly examined all the higher Crustacea obtained, reports as follows :—"The total number of species of Malacostraca taken is 108, made up as follows :— Decapoda 23, Cumacea 2, Euphausiacea 2, Isopoda 5, Amphipoda 76.

"Of these, the following do not appear in Canon A. M. Norman's list of Crustacea collected in the Shetland Seas in 1861–7 (Report, British Association, 1868) :— *Nephrops norvegicus* (Linn.), *Philocheras sculptus* (Bell), *Eudorella emarginata* (Kr.), *Campylaspis glabra*, G. O. Sars, *Conilera cylindracea* (Mont.), *Lysianassa ceratina*, A. O. Walker, *Tryphosa Höringii*, Boeck, *Socarnes erythrophthalmus*, Robertson, *Hippomedon denticulatus* (Bate), *Metaphoxus fultoni* (Scott), *Neopleustes assimilis* (G. O. Sars), *Maera tenuimana* (Bate), *Gammarus duebeni*, Lillj., *Jassa pusilla* (G. O. Sars), and *Corophium bonellii*, M. Edw."

A specimen of *Munida bamffica*, dredged in the Minch, showed on one side the swollen carapace indicative of a Bopyrid parasite. Mr. T. R. R. Stebbing has kindly examined the specimen for me, and finds that the cavity contains

only the small male of a species of *Pseudione*. The *Munida*, we find, is also infested by a Rhizocephalan parasite, the *Triangulus munidæ* of Geoffrey Smith *—probably a new record for the British fauna.

(7) Miss L. R. Thornely, who has examined and identified the Polyzoa collected on the cruise, reports to me a list of 52 species, some of which are of considerable interest — one (*Mucronella abyssicola*) having been previously recorded from the Shetland Seas only. Our specimen was obtained from the Minch, off the west coast of Skye. *Lepralia polita* and *Idmonea atlantica* are also worthy of note.

(8) Knowing that Mr. E. Heron-Allen and Mr. A. Earland were engaged on a 'Monograph of the British Foraminifera,' it occurred to me when arranging the work of this cruise, that samples of our dredged deposits might possibly fill some gaps in their list of localities.

Mr. Heron-Allen supplied us with two dozen canvas bags which were duly filled with fair samples of the unwashed mud, sand, or other material as it was emptied from the dredge on to the deck.

These samples are now being examined, and Messrs. Heron-Allen and Earland report as follows in regard to them :—

"It has been a matter of great satisfaction to us that we have been entrusted with this series of samples. Apart from any intrinsic merit or interest which they possess in themselves, they greatly enrich, and fill gaps in, the collection of material already at our disposal from these seas, linking up as they do the 'Goldseeker' dredgings with the work of Messrs. Balkwill and Millett in the Galway District, our own in the Clare Island District, and that of Mr. G. Wright on the 'Helga' and other dredgings off the west and south-west of Ireland.

"So far, four bags of material have been examined, with results at once satisfactory and surprising. Indeed, whether the material is a shore-sand or a dredged mud, Miss Catherine Herdman, to whom we understand we owe the collection of the samples, seems to have displayed an unerring instinct for those muds and sands which were exceptionally rich in quantity of specimens and quality of species.

"In Sample No. 1 (At anchor, Lowlandman's Bay, Jura, 5 fms.), in addition to a series of 20 species of the genus *Lagena*, we have found the family of the Textularidæ very finely represented, the otherwise dominant form being a robust and highly papillate *Rotalia* of the *beccarii* type, attaining remarkable dimensions in enormous quantities. The Station yielded 89 species.

"Sample No. 2 (Dredging, Sound of Mull, 20 fms.), which reached us as a cake of hard black mud, 254 c.c. in bulk, became on the sieve 5 c.c. of fine material, which yielded 107 species. The dominant feature of the dredging

* This specimen has since been examined by Mr. Geoffrey Smith, who finds that this fresh material enables him to correct the description in his Naples Monograph and to show that these parasites of *Munida* should be included in the genus *Lernæodiscus*, the other members of which are also parasitic on the Galatheidæ.

was the presence of many hundreds of the rare species *Ammodiscus charoides*, Jones & Parker sp. Among the 39 species of Lagenidæ, were fine specimens of *Nodosaria filiformis*, d'Orbigny, *N. vertebralis*, Batsch sp., and *N. roemeriana*, Neugeborer, and *Sagrina nodosa*, Parker & Jones.

"Sample No. 3 (Dredging, Shell Bank, off Ardnamurchan, 20 fms.), was a large bag (2335 c.c.) of fine and coarse clean brown shell debris which yielded 128 species, many being represented by relatively gigantic specimens, e. g., *Vaginulina legumen*, Linné sp., *Polymorphina gibba*, d'Orbigny, and *P. sororia*, Reuss (both highly fistulose), and *Pulvinulina repanda*, Fichtel & Moll sp. attaining sizes of 1–3 mm. The sample yielded also *Crithionina mamilla*, Goës, *Reophax findens*, Parker sp., and *R. moniliforme*, Siddall, *Lagena ornata*, Williamson, *L. spumosa*, Millett, and remarkable specimens of *L. marginata*, Walker & Boys sp., *Gypsina vesicularis*, Parker & Jones sp., and many other rare species.

"Sample No. 4 (Dredging, Loch Sunart, 20 fms.), is not yet completely worked out, but has already yielded 140 species, including *Frondicularia spathulata*, Brady, and *Bulimina subteres*, Brady, from a block of harsh grey mud of 1000 c.c. bulk. The dominant forms are *Nodosaria scalaris*, Batsch, and *Nonionina umbilicatula*, Montagu sp., with a very complete series of Buliminæ, showing every gradation from *B. elegans*, d'Orbigny, through *B. pupoides*, d'Orb., and *B. marginata*, d'Orb., to *B. aculeata*, d'Orb.

"So far as we have been able to clean the material, the shore-sands promise to give results not less rich than the dredgings we have already examined, and we hope, in the near future, to contribute to Prof. Herdman's series of 'Spolia Runiana' a paper on this very remarkable series of gatherings."

Mr. Heron-Allen has very kindly sent me a list of the 259 species of Foraminifera which he and Mr. Earland have found in the four samples which they have up to now examined. But I do not include the list here, as it is probable that the remaining 20 bags will add materially to the record which I hope they will publish in full when the work is completed.

II. Funiculina quadrangularis (*Pallas*).

At the end of the statement which I made last year in regard to the limited distribution of this magnificent Pennatulid, I ventured to add: "I do not doubt that other localities will yet be discovered on the West Coast of Scotland containing virgin forests of this largest and stateliest of the British Cœlenterata." In this year's work we have added four localities to those previously known, viz.: (1) Loch Sunart, near the mouth, opposite Tobermory, 22 fathoms; (2) Loch Nevis, to the east of Tarbet Bay, 30 to 40 fathoms; (3) Loch Hourn, off Piper Island, 20 fathoms, and also further up near the "narrows"; (4) Loch Shell, in Harris, 25 to 30 fathoms—in all cases from a muddy bottom. The original locality, near Oban, between the islands of

Kerrera and Lismore, in the Firth of Lorn, is, however, the spot where this giant "sea-pen" seems to live in greatest abundance and to attain to the largest size (62 inches is still my greatest recorded length of colony). It is pretty clear now that *Funiculina quadrangularis* is widely distributed in the more sheltered sea-lochs of Scotland, at depths of about 20 fathoms and upwards *, and always embedded in a bottom of stiff mud.

The abundance of *Funiculina* material we obtained in the Firth of Lorn this year, enabled us to keep some alive, under observation, in baths and basins on deck, and to record the colours in the living expanded condition and also the phenomena of its "phosphorescence." Professor Newstead photographed for me some colonies, living in a long tube of sea-water, where the polypes had expanded to a length of nearly an inch (see Pl. **19**. fig. 1).

In regard to the "phosphorescence" or luminosity, we were able to watch the colour and distribution of the light emitted both (1) when observed freshly dredged (a very few minutes after being taken from the sea) in an excellent make-shift dark-room—the lazarette of the yacht ; and also (2) some hours afterwards, lying in their basins of sea-water on the deck at midnight. In the two cases the phenomena were the same, and it was noticed that the distribution of the light is quite different from that in the better-known *Pennatula phosphorea*. In the latter form the light appears to be restricted to the polypes. I have not been able to excite any luminosity in the stem portion of the Pennatula colony, but illumination of the polypes is very general and beautiful—more general and more lasting than the luminosity of that part of the colony in *Funiculina*.

In *Funiculina quadrangularis*, however, while there are many distinct sparkles scattered over the polype-bearing part of the colony (corresponding, no doubt, to the individual polypes), the long, bare lower part of the stem, 9 inches to a foot in length, when gently stroked in the dark glows with a continuous sheet of light of (it seemed to me) a pale green † colour which flickers or pulsates like a lambent flame. The light on this bare part of the colony is certainly more intense than that of the polypes, and is, I think, the most brilliant "phosphorescence" I have seen in any marine animal.

During the cruise a letter was received from Professor Hickson asking me if I found the allied smaller sea-pen, *Virgularia mirabilis*, to determine, if possible, whether that form was phosphorescent and could sting. As both of the other British Pennatulids, *Funiculina* and *Pennatula*, had been exhibiting a brilliant display of light, I fully expected to find the *Virgularia* was also luminous ; and was therefore rather astonished, when we did dredge a couple of colonies of *V. mirabilis* in Loch Nevis, to notice that, although stimulated in various ways in the dark, not the slightest trace of

* Sir Wyville Thomson records having dredged it in abundance in the Sound of Raasay from a depth of 100 fathoms, on the 'Porcupine' Expedition.

† Wyville Thomson in 'Depths of the Sea' refers to the "lilac phosphorescence" of *Funiculina*.

light was visible ; while small *Funiculina* colonies, dredged at the same time and treated in the same way, were phosphorescing freely. I did not notice any stinging or numbing effect in handling any of the above-mentioned three species of Pennatulids.

The colour notes which I made from the living *Funiculina* are as follows :—The stem of the colony is pale yellow to ivory-white in tint, quite opaque in the centre and translucent along the edges. In an expanded polype, measuring about three-quarters of an inch in its free part, the lower half inch or so is translucent and of a greyish colour. The upper, or distal, quarter inch, where the stomodæum and the mesenterial filaments show through, varies from an opaque yellow to an orange-red—the stomodæum being the yellower part and the mesenterial filaments the redder. The expanded tentacles are of a delicate pinkish white, and the edge of the mouth is marked by a narrow line of opaque yellow. The blending of these colours, when seen at a little distance, gives the general orange-pink effect which is characteristic of the expanded polype fresh from the sea.

In a colony a little over three feet in length (say one metre) the largest polypes, when fully expanded, measured about $\frac{3}{8}$ of an inch in the length of their free part projecting above the stem (see Plate **19**. fig. 1). The spiral arrangement of the polypes upon the stem is very evident in the living colony.

This abundant fresh *Funiculina* material has enabled us to fill a gap in the knowledge of its minute structure. The Marshalls, in 1882, were unable to find in their Oban specimens any trace of the male gonads, and the male *Funiculina* has remained undescribed to the present day. Miss H. Muriel Duvall, B.Sc., a post-graduate worker in my laboratory, has been examining with me some of the fresh *Funiculina* material plunged living into 10 per cent. solution of formalin in sea-water, and we have been fortunate enough, after some searching, to find the missing male gonads. They were found first in a moderate-sized colony of a much paler colour (in formol solution) than the pinker ones in which we were finding the mature female gonads.

The male gonads of *Funiculina* are of much the same appearance and structure as those of *Pennatula*. They are globular masses (spermospheres) of rather smaller size than the mature ova, and consist of an external cellular capsule, a distinct structureless membrane (mesoglœa), and a central mass of small nucleated cells which evidently, as the gonads mature, increase greatly in number and become radially fusiform, and are then packed together in masses running inwards from the wall towards a central space. Out of seven colonies we have now examined, three were male and four female, the males being rather the smaller and so distinctly paler in colour that, after seeing the first one, Miss Duvall successfully predicted which of the remaining colonies would prove to be male.

III. Diazona violacea, *Savigny*.

I have this year been extraordinarily fortunate in obtaining abundance of material of this remarkable species. Previous to my record of last year, I believe only two specimens were known from Hebridean Seas—the one described by Forbes and Goodsir in 1851 as "*Syntethys hebridicus*" and the colony which I noted in 1891 * as having been dredged by the late Duke of Argyll, north of Mull, in 1885. Last year I found one good colony off Barra Head in the Outer Hebrides, and a few small fragments from the East Shiant Bank in the North Minch. This year I dredged over 30 colonies —most of them from a bank in the Inner Sound, north of the Croulin Islands †, at a depth of about 30 fathoms, but some off the West coast of Skye across the mouth of Loch Snizzort, outside the Ascrib Islands, from 30 to 40 fathoms.

At the Meeting of the British Association at Birmingham last September, I exhibited to the Section of Zoology two large museum jars, the one containing several bright violet colonies of *Diazona* preserved in alcohol, while the other had an equal number of colonies preserved in a solution of formol and still showing distinctly the green colour of the living animal. The contrast in appearance between the two jars was most marked, and was due merely to the method of preservation, all the colonies having been equally green when placed alive in their respective fluids. In the discussion, I was then asked the question—What will be the result if you now put one of the green formol-preserved specimens into alcohol? I am now able to answer that question as follows :—

On September 24th I washed one of the colonies from the green jar in running fresh water for a couple of hours, to remove the formol from the surface, and placed it in absolute alcohol at 5.40 P.M.

Up to 6.0 P.M. no change was visible.

September 25th, 9.30 A.M., the alcohol was tinged with green and the colony looked paler.

September 26th—the alcohol was much greener.

October 2nd—handed the green alcohol over to Dr. A. Holt for chemical examination, and transferred the colony, now of a pale green colour, nearly colourless in places, and of crystalline appearance on the surface, to a jar of new colourless alcohol.

October 3rd—the alcohol beginning to be green.

October 4th—fluid still greener ; colony seems colourless on surface.

November 4th—there has been no further change for some weeks. The

* Ann. & Mag. Nat. Hist. for August 1891 (ser. 8, vol. vi.), p. 165.

† This is probably the same spot from which Forbes and Goodsir, when on Mr. R. McAndrew's yacht in 1851, dredged the first-described specimen of "*Syntethys*."

fluid is distinctly yellow-green. The colony when taken out of the alcohol is now of a light yellowish-grey tint, but has very little colour. No violet has appeared in any part.

It seems, then, that the change from green to violet, as the result of preservation in alcohol, can only be effected in the case of the living, or at least unfixed, animal; and that the specimen which has been preserved in formol, although it will still give out a green colour when treated with alcohol, does not become violet.

A further new point I have now to state, in connection with the colour-changes of this Ascidian, is that even the living colony exposed in a vessel of sea-water to bright sunlight for a few days changes its colour to a notable degree, and may even develop a certain amount of violet or blue coloration on the surface of the colony. The abundance of material obtained off the Croulin Islands enabled me, after preserving some specimens in a tank of spirit (these became violet at once), and others in a jar of 10 per cent. formol (these remained green), to allow others to remain alive in basins of sea-water on deck under observation.

The first change noted was that the green Hebridean *Diazona* becomes distinctly greener during the first hour or so of exposure to sunlight. When brought up fresh from a depth of 20 or 30 fathoms the colony is of a delicate grey-green colour and has a gelatinous translucent appearance. But the green soon becomes more vivid and opaque, and the colony is then more solid in appearance. The green, after the lapse of some hours, then changes gradually from a yellow-green to a still more opaque and darker green, and then to a blue-green. After two or three days' exposure to light (the sea-water in the basins was frequently renewed during these observations) the colour of the colony round its margins, and especially in the upper parts of the test occupied by the ascidiozooids, became distinctly bluish, bluish violet, or slate-blue, usually very much of the tint of freshly spilt "Stephens's blue-black" ink—and in this condition it remained. Some of the colonies after a few days further captivity, were evidently dead or moribund; the others we preserved in the tank of spirit, and they are now all violet in colour like the rest.

Up to the last, however, the change in colour is only superficial, affecting at the most the outer quarter to half inch in thickness of the test. Similarly, the change to violet in the case of specimens preserved in alcohol, deep and opaque though the colour may seem, affects only the surface-layer of the test. Even now, after some months preservation in several changes of spirit, if a colony be cut open the centre is found to be of a vivid green colour; and it is interesting to notice that that green is now permanent, even when exposed to clean alcohol. Apparently the change to violet only takes place in the case of the fresh specimen taken from sea-water and placed in spirit.

As specimen after specimen of the living ascidian went through the same series of colour-changes before our eyes this summer, it is probable that we have seen all that can be determined from observation of the living animal, and that any further investigation of the pigmentation must be undertaken by the chemist in the laboratory.

Dr. Alfred Holt, of the Physical Chemistry department of the University of Liverpool, has kindly undertaken to investigate the pigment or pigments of these Hebridean colonies of *Diazona* from the chemical point of view. He reports to me as follows on his investigation so far :—

"Animal investigated was purple outside, but yellow-green inside. The purple and yellow-green portions were investigated separately.

"(1) *Purple part.*—Cut up into small fragments or ground with sand and then extracted in a Soxhlet with absolute alcohol, the colour gradually passed into solution. The solution thus obtained was bluish green in colour, quite distinct from the colour of the inner part of the animal or from the alcoholic solution obtained from the fresh animal on capture. This blue-green solution on evaporation at a low temperature (below 100° C.) gave a small residue which by transmitted light had no decided colour, but by reflected light was purple, identical in colour with that of the animal. The colour was soluble again in alcohol or zylene, solution taking a long time. The zylene extract had a more pronounced blue tint than that in alcohol.

"The addition of alkali to the blue-green solution changed the colour to a greenish yellow.

"(2) *Green part.*—The colouring matter of the inner green part was very easily soluble in alcohol to a green solution, the colour of which was, however, far more yellow than that of the purple part. On evaporation at low temperature this yellow-green solution yielded a green residue, not purple, and was again easily soluble in alcohol. The addition of alkali did not materially change its colour.

"The green parts of the animal did not go purple in alcohol. The fresh animal preserved in formaldehyde maintained its green colour, and this was readily and completely soluble in alcohol.

"Acid had no marked effect, nor acid nor alkaline hydrogen peroxide in dilute solution.

"From the absorption spectrum and general characters it would seem that the pigment in the purple portion is very similar to that obtained by Friedländer from *Murex brandaris*, and which was subsequently shown by him to be an indigo derivative. If this be so, then the yellow-green colour of the alcoholic solution from the inner (not purple) portion of the animal can scarcely be due to this pigment. Microscopic examination of this part shows numerous globules containing what looks like a yellow oil, and it is probably the solution of this oil that gives the yellow-green colour to the alcohol. The particular shade of tint may vary, depending on the

amount of the blue purple (indigo ?) dissolved in the yellow oil, and so producing a greenish shade. Attempts are at present being made to extract the colouring matter by Friedländer's method and so prove its chemical nature."

Dr. Holt proposes to publish a paper later on his chemical investigation of these pigment changes.

The fresh material has enabled me to make some further observations on the arrangement of the ascidiozooids as seen in the living and expanded colony. It is clear that, in some colonies at least, the ascidiozooids are not placed evenly over the whole of the upper surface, nor are they scattered irregularly, but are arranged in definite rows or groups with meandering branching paths of smooth depressed test between. So that, looking at the top of the expanded colony from above, one sees certain bare areas of test, as shown in Plate 19. fig. 2. In all probability this grouping of the ascidiozooids is the result of lines of budding in the growth of the young colony. In Alder and Hancock's 'British Tunicata'* the arrangement of the ascidiozooids is described as "forming a single, irregular, or very indistinctly concentric system"; but there is no reason to regard this as forming a single "system," and the arrangement is certainly not concentric.

In fig. 3, I show the arrangement of the "ocelli" or pigment spots in relation to the branchial and atrial siphons and also the lines of snow-white pigmentation on the thorax, as these structures are not represented correctly in Forbes and Goodsir's figures. There are six ocelli at the atrial aperture and none at the branchial, but a circle of white pigment spots surrounds the base of the branchial siphon, a short row of dots runs from this in the mediodorsal line to the nerve ganglion, a double line of white pigment bounds the endostyle along the ventral margin of the branchial sac, and two parallel white bands run along the dorsal edge of the thorax, terminating anteriorly in a single row of white dots facing that of the ganglion on the opposite side of the atrial siphon (see fig. 3). Each siphon terminates in six lobes.

IV. The Systematic Position of *Forbesella tessellata* (Forbes).

This West Coast species was first described by Forbes in 1848† as *Cynthia tessellata*. Forbes's specimens were dredged by McAndrew in Mounts Bay, Cornwall, from 25 fathoms, and the species has since been found in deep water at several localities round the South and West coasts. In 1891, from the examination of some specimens dredged off the west of the Isle of Man, I drew attention to the fact that this species seemed to occupy an intermediate position between the subfamilies Cynthiinæ and Styelinæ, agreeing with the former in the compound tentacles and with the latter in having only four

* Edited by Hopkinson, Ray Soc., vol. ii. 1907, p. 159.

† British Mollusca, vol. i. p. 38.

folds on each side of the branchial sac. In my "Revised Classification of the Tunicata," read before this Society in February 1891 *, I therefore placed the species in a separate genus, *Forbesella* ; and in 1893 † I redescribed and figured it in more detail. In 1892 Lacaze-Duthiers and Delage ‡, from the examination of specimens found off the coast of Brittany, quite independently came to the same conclusions as my own, and had proposed to form for the reception of this species a new genus "*Forbesia*" ; but on receiving my paper of 1891 they accepted the generic name *Forbesella* there-in defined.

More recently Hartmeyer, in the new edition of Bronn's "Tier-Reichs," 1909, p. 1335, places both *Forbesella* and *Forbesia* as synonyms of his genus *Pyura*, the modern equivalent of *Cynthia*. His defence for so doing is that what seem the two most notable characteristics of *Forbesella tessellata*, namely, the tessellated or plate-like condition of the test and the small number of folds in the branchial sac, are both characters that are found in other species which he brings under his comprehensive genus *Pyura*. It may be remarked, however, that even on his own showing the combination of these two characters is not found in any other species ; but, apart from that, it is quite questionable whether species showing such a small number of folds in the branchial sac ought to be placed in *Pyura* (= *Cynthia*). In his discussion of the matter Hartmeyer states that two or possibly three species show five folds on each side, and that one (*Pyura stubenrauchi*, Meichaelsen) has on each side only four folds. The species that have five folds on each side I would regard as undoubtedly members of the genus *Pyura* or *Cynthia*, but the species with only four folds, if the existence of that character as a normal condition is established, I would unite with the species *tessellata* in the genus *Forbesella*. The species *Cynthia stubenrauchi* of Michaelsen § was described from a single preserved specimen brought home from the Straits of Magellan. In such a case it is of course quite possible that the single specimen examined was an abnormal individual, and I doubt whether on such evidence we are justified in making the proposed change in our classification.

I make a considerable distinction between the presence of eight folds and of ten. Four folds on each side is a well-marked character of the subfamily Styelinæ (according to some authors the family Styelidæ), while the Cynthias have a variable number of folds, from five on each side upwards. In discussing such matters of classification one must look at the problem from the standpoint of phylogeny. The ancestral Styelinæ and Cynthiinæ diverged presumably when their common ancestors had four folds on each side of the branchial sac, and thereafter the Styelas seem to have fixed the character of

* Journ. Linn. Soc., Zool. vol. xxiii. p. 558.

† Journ. Linn. Soc., Zool. vol. xxiv. p. 451.

‡ Mém. Acad. Sci. Inst. France, t. xlv. No. 1, p. 137.

§ Zoologica, Bd. xxxi. p. 102 : Stuttgart, 1900.

four folds in their line of descent, whereas the Cynthias acquired a greater number. In addition there is the further characteristic derived from the condition of the tentacles, which remained simple in Styelids and became compound in the Cynthiidæ. In my opinion, then, we are justified in considering that a species which presents us with only four folds on each side must be excluded from the genus *Cynthia* or *Pyura*; but as it has compound tentacles it must equally be excluded from the genus *Styela*. Therefore I would place both Forbes's *tessellata* and Michaelsen's *stubenrauchi*, if the latter has undoubtedly not more than eight folds, together in the genus *Forbesella*, occupying an intermediate position between *Styela* and *Cynthia*, and representing an early offshoot from the ancestral Cynthiids after they had attained compound tentacles, but before the number of folds in the branchial sac had increased beyond a total of eight.

I have now before me a series of specimens of *Forbesella tessellata*, obtained during the cruise of the 'Runa,' from five localities on the west of Scotland, viz. :—

(1) Loch Sunart, 20 fathoms.
(2) Off Island of Canna, 60 fathoms.
(3) South of Neist Point, Skye, 42 fathoms.
(4) Off the Croulin Islands, 30 fathoms.
(5) Inner Sound north of Croulins, 50 fathoms.

This series demonstrates clearly the very definite nature of the flat plates or scales into which the test is modified, and which are much more perfect and regular than the rough tubercles or surface elevations found in some species of *Cynthia*. I give (Pl. 19. fig. 4) a tracing with the "Edinger" drawing-apparatus to show the very definite polygonal shapes and arrangement of these plates from one of my Hebridean specimens.

The internal structure of these northern individuals agrees, so far as I have examined it, very closely with that of specimens from the Isle of Man. The branchial sac again, as in the former specimens, shows some variations; but in all cases the folds never exceed four on each side, which, taken along with the compound tentacles, in my opinion places this curious little form in an intermediate position between *Cynthia* and *Styela* and entitles it to rank as a distinct genus, *Forbesella*, in the subfamily Cynthiinæ.

V. Variation in *Ascidia*.

The large specimens of *Ascidia mentula*, Müll., and *Ascidia venosa*, Müll., which came up in the dredge on various occasions suggested to me that it might be useful to examine the individual variation in some of the internal organs which are usually described among the specific characters of these two well-marked species.

Ascidia mentula and *A. venosa* * are easily distinguished by their external appearance. Amongst more than a hundred specimens collected and preserved there was not a single doubtful case. Although individuals vary to some extent, especially in *A. mentula*, still every specimen can at a glance be referred to one or the other species.

I had removed a number of the freshly-dredged specimens of both species from their tests, thinking that this would ensure better preservation; but examination of the material now shows that this was a mistake, as these "skinned" specimens are so contracted and distorted as to be much less suitable for investigation than those specimens where the test was left as a support to the more delicate tissues within.

We † picked out ten well-preserved specimens of each species and made microscope preparations of the wall of the branchial sac, of the entire series of branchial tentacles, and of the dorsal tubercles, with the following results :—The specimens of *Ascidia mentula* ranged in length (antero-posterior) from 12 to 16 cm. The tentacles were found to vary in number from 39 to 103, and the number seems to bear no relation to the size of the body, since the individual with only 39 was actually larger than the one with 103 tentacles. The most usual number for the tentacles is from 60 to 90 ‡. The tentacles are always of more than one size §, and usually three distinct sizes or orders are present. The proportion of those of the first (largest) order to the rest varies from one-ninth to one-half—one-third ‖ being the proportion most frequently found. As *Ascidia mentula* usually lies attached with the left side downwards, it would not be surprising to find that some of the apparent irregularities in size and position of the tentacles bore some definite relation to the two sides of the body, but no such relation exists. In some specimens it is the right and in others it is the left side that has the largest or the greatest number of tentacles. One individual examined had 4 tentacles of the first order on the right side and 3 on the left, while another with 4 tentacles on the right side had no less than 11 on the left. There is a considerable range of individual variation in the spacing of the tentacles, which may be densely crowded (Pl. **19.** fig. 7) or sparsely scattered (fig. 5), or show intermediate gradations. Figures 5 and 6 show the

* We are not at the moment concerned with the question whether or not it is convenient to separate *venosa* in an independent genus *Ascidiella*.

† Miss H. M. Duvall, B.Sc., a post-graduate worker in my laboratory, has kindly assisted me in this investigation.

‡ In the L. M. B. C. Memoir on "Ascidia" I find that, as the result of a number of specimens examined, I then gave the number characteristic of the species as being from 70 to 100.

§ In Alder and Hancock's 'British Tunicata,' vol. i. (1905), under *Ascidia mentula*, we are told on p. 76 that the "tentacular filaments" are of "equal length," while on p. 79 they are said to "vary considerably in size." The latter is the more correct statement.

‖ This agrees with what is stated in the L. M. B. C. Memoir.

extremes found in one and the same individual: in these examples the tentacles are in the proportion of 4 to 9 in a given space. We are of opinion, however, that the unequal crowding of the tentacles in places is due in part to unequal contraction of the sphincter muscles. Consequently, individuals probably do not differ so much from one another as might be supposed, and authors in describing the condition of the tentacles would do well to take the state of contraction of the sphincters into consideration. The apparent crowding on the dorsal and ventral edges which is sometimes seen is mainly due to muscular contraction.

Calling the tentacles of the first, second, and third orders 1, 2, and 3, the normal scheme of arrangement in *Ascidia mentula* is :—1, 3, 2, 3, 1 (see fig. 8) ; but there is much individual variation: the third order of tentacles is especially variable, and in places where they are crowded those of the third order are liable to be squeezed out and the remaining tentacles then appear more equal in size.

The specimens of *Ascidia venosa* examined ranged from 7 to 11 cm., and the tentacles varied in number from 38 to 74—the most usual number being from 40 to 50. In this species also there seems to be no correlation between the number of tentacles and the size (probably =age) of the individual. The average proportion of the largest tentacles to the rest is one-half. Here, again, as in *A. mentula*, there is no correlation between the arrangement of the tentacles and the right and left sides of the body.

In making a comparison between *A. venosa* (fig. 9) and *A. mentula* (figs. 5 to 8), we find that the tentacles in the former are more slender, have a smaller range in number, and show less variation in size and arrangement and spacing, and any crowding noticed seems to be due to muscular contraction.

Turning now to the Dorsal Tubercle in the same specimens of these two species, we find that it is distinctly smaller in *A. venosa* than in *A. mentula*. The typical form in *A. mentula* is a horseshoe shape with the two free ends, or "horns," turned in the same direction, say to the right side, so that the right-hand horn turns outwards and the left inwards. The commoner variations are that both horns may turn to the left side, or both turn inwards, or one turn inwards and the other remain straight or nearly so. Out of the ten dorsal tubercles examined, six have at least one horn turned to the right.

In *Ascidia venosa* the typical form is a deep U-shape. Out of the ten specimens examined eight are simply U-shaped, and two have one horn turned inwards.

Finally, we examined the condition of the branchial sac in the same two series of individuals. In comparing branchial sacs it is desirable to examine pieces taken from corresponding parts of the wall ; and, in fact, the samples we have made use of were all cut out from the centre of the right-hand wall about the middle of its length.

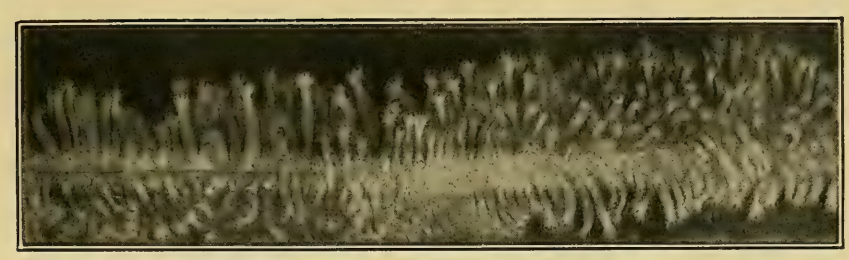
In *A. mentula* the usual characters of the branchial sac seem to be as follows :—There is well-marked "plication" of the wall, intermediate papillæ are always present on the internal bars halfway between the transverse vessels, the stigmata are wide and short and vary from 5 to 16 in a mesh—the usual numbers being from 9 to 12.

In *A. venosa* the plication of the wall is much less marked, there are no intermediate papillæ (except occasionally where a range of stigmata is in process of dividing into two—and in that case the papillæ are not really "intermediate" as they will eventually be at the angles of meshes), the stigmata are longer and narrower and more regular, and vary in number from 7 to 15 in a mesh, the usual numbers being from 8 to 12.

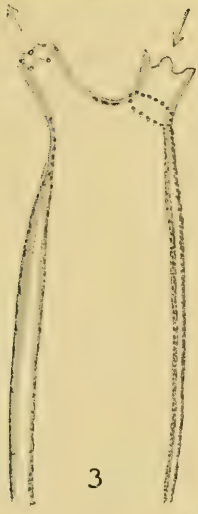
If we now attempt to draw some conclusions from these studies of the variation of the internal organs which are considered of most importance in defining the species, they must be to this effect :—*Ascidia mentula* and *A. venosa* can always be easily distinguished from one another by the external appearance either alive or when preserved. They may also be readily distinguished when stripped of the test. In the hundred or more specimens which we have just passed through our hands there has never been the least doubt as to which species each individual belonged to. Of the two, *A. mentula* is the more variable. Then, again, when examining the microscopic anatomy of the internal organs, such as the branchial sac, there is a general facies which is found to be characteristic of the organ in each of the species and which in most cases enables one to name the species correctly. But it is important to note that in these organs the range of individual variation in what are usually regarded as specific characters may, as we have seen, be very wide, and the extremes of the one species may reach to or even overlap those of the other. Consequently, it might be difficult in the case of a given preparation of an organ, say branchial sac or tentacles, placed under the microscope to determine the species with certainty, but even in that case if the other internal organs are available for examination, from the combination of characters there ought to be no difficulty in making a correct identification.

These two species which I have chosen out first for the purpose of such a comparison of their characteristics are very distinct from one another—so much so, in fact, that they are sometimes placed in separate but neighbouring genera, *Ascidia* and *Ascidiella* *. I am afraid, when one comes to deal in this manner with the variations in other more closely related so-called species of *Ascidia*, it will not prove such an easy matter to discriminate and define. There is no doubt that such investigations ought to be made whenever large series of individuals can be obtained, and I feel pretty sure that the work

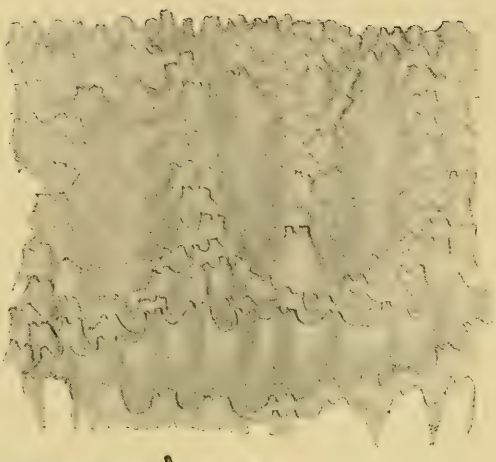
* Separated off mainly on account of the relative positions of the nerve-ganglion and the dorsal tubercle.



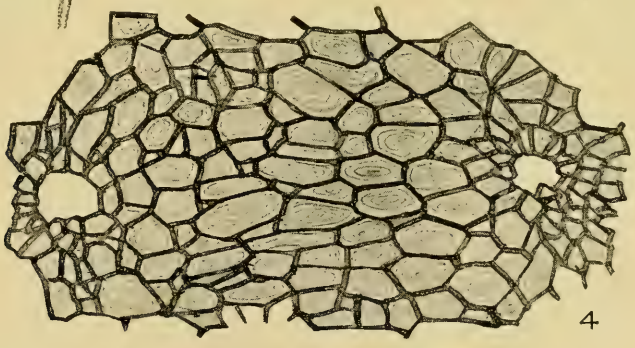
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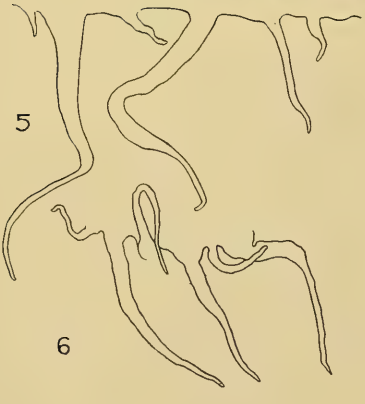
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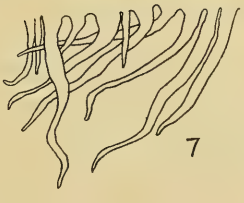


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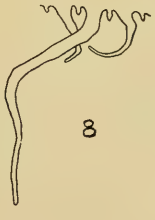


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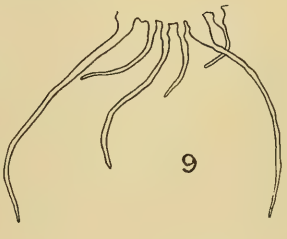
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W. A. H. del. Grout sc. & imp.

SPOLIA RUNIANA.

will result in a considerable number of the named and described British Ascidians being shown to have no existence as distinct species. That will probably be the fate of some of the supposed species described by Hancock, and by myself and others, from single specimens in some cases preserved in spirit and possibly distorted. These descriptions may have served a useful purpose at a certain stage in our knowledge of the group, but the names may eventually in the light of further study and comparison have to be removed from the list of valid species.

I had hoped to have included in the present study some further series of common forms of Ascidians which I had collected from the 'Runa' for the purpose; but other work has come in the way, and they must now be left over for some future occasion when I shall hope to publish the results in another part of "Spolia Runiana."

EXPLANATION OF PLATE 19.

Fig. 1. *Funiculina quadrangularis* (Pallas), alive and expanded in a cylinder of sea-water—about half natural size. From a photograph.

Fig. 2. *Diazona violacea*, Sav., alive and expanded to show the arrangement of the ascidiozooids; reduced a little.

Fig. 3. Anterior end of an ascidiozooid of *Diazona violacea* to show the arrangement of the lines of white pigment on the thorax. Enlarged.

Fig. 4. *Forbesella tessellata* (Forbes), upper surface of the test to show the plates. Enlarged.

Figs 5 to 8. *Ascidia mentula*, Müll., showing variation in tentacles.

Fig. 5. Sparsely scattered arrangement of tentacles.

Fig. 6. More crowded condition found in another part of the same individual.

Fig. 7. Densely crowded arrangement of tentacles.

Fig. 8. The typical arrangement of the tentacles in *A. mentula*.

Fig. 9. Tentacles of *Ascidia venosa*, Müll.—Figs. 5 to 9 all enlarged about 10 times.

On the Range of Variation of the Oral Appendages in some Terrestrial Isopods.

By Walter E. Collinge, M.Sc., F.L.S., F.E.S.

(Plates 20 & 21.)

[Read 5th February, 1914.]

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I. Introduction.

In classifying the different Orders of animals, zoologists have endeavoured to separate species and genera from one another by certain characters which are constant for a particular genus or species; thus in Insects the form of the antennæ and the venation of the wings has been largely used, in Molluscs the generative organs and nervous system.

Many of the systems propounded by earlier writers have been discarded because the characters relied upon for this separation, have on further study, been found to vary greatly in individual species and therefore to be unreliable.

In the various attempts that have been made to classify and diagnose the different genera and species of Terrestrial Isopoda, students have laid particular stress at different times upon the shape and form of almost every part of the external structure.

Considerable reliance has of recent years been placed upon minute differences in the oral appendages, and the object of the present paper is to show that these particular appendages are liable to a large amount of variation in individual species, and are therefore characters of only minor importance as compared with the form of the head, antennæ, telson, uropoda, mesosomatic segments, and thoracic appendages.

Lereboullet (Compt. Rendus, 1849, xx. p. 346) stated that in his opinion the oral appendages are in no case available for characterizing the genera and

species, and Miers (4) was of a similar opinion. The late Dr. Budde-Lund, however, whose ripe experience and wide acquaintance with the terrestrial species of this Order made his judgment so valuable, placed the greatest reliance upon these organs (1 & 2).

Restricting my remarks to the genera occurring in the British Isles, an examination of the oral appendages shows that in most of them the form of the mandibles and 1st and 2nd maxillæ are very similar, *e. g.*, the two maxillæ in such widely separated forms as *Oniscus asellus*, Linn., *Philoscia muscorum* (Scopoli), *Cylisticus convexus* (de Geer), and *Armadillidium vulgare* (Latreille) ; and linking these together, we have a large series of Continental forms in the same genera, so that a perfect gradation can be shown to exist.

Whilst working upon our British species, and also those of other countries, I have noted that there is a considerable amount of variation in the oral appendages according to the age of the specimen, and further, that other variations occur, due, in all probability, to the nature of the food, environment, etc. This being so, it seemed desirable to examine a fairly large number of examples of representative species, and the results obtained considerably lessen, in my opinion, the value of these organs as characters for generic and specific distinction.

The shape of the head, antennæ, the mesosomatic segments, the telson, and uropoda I would regard as of primary value ; that of the thoracic appendages as of secondary, whilst the value of the abdominal and oral appendages as diagnostic features I believe to be very much less.

I have only arrived at this opinion after examining a considerable number of specimens of a fairly representative series of species.

II. Species Examined.

The species examined and the number of examples and variations and the times they occurred are as follows:—

Species.	No. examined.	No. of Variations.	No. of times occurred.
1. *Lig a oceanica*, Linn.	36	4	7
2. *Trichoniscus roseus* (Koch)	48	1	9
3. *Oniscus asellus*, Linn.	112	13	39
4. *Porcellio scaber*, Latr.	88	7	22
5. „ *lævis*, Latr.	36	1	5
6. *Porcellionides pruinosus* (Brandt)	68	4	20
7. *Armadillidium vulgare* (Latr.)	51	3	8
	439	33	110

Unless otherwise stated all the variations occurred on both sides of the body.

1. Ligia oceanica, *Linn.* (Pl. **20.** figs. 1–4.)

Thirty-six specimens have been examined and four variations, one in each of the oral appendages, have been observed. The one in the mandibles occurred twice and on the right side of the body only in both cases, that in the first maxillæ once, and those in the second maxillæ and maxillipedes each twice. The specimens examined were collected from two localities.

The Mandibles.—The variation shown in fig. 1 occurred twice. In the curved form of the teeth, it is quite distinct from the figure given by Sars (**5**) and approaches most closely that given by Hewitt (**3**).

The 1st Maxillæ.—The only variation noted was in a single specimen from St. Andrews (fig. 2) in which the setose bristles of the inner lobe were larger than usual and the short thick spines of the outer lobe reduced to two, the distal extremity of the lobe forming a knob-like process.

The 2nd Maxillæ.—In two examples the terminal portion of the protopodite was thickened and the two setose bristles rather larger than usual, whilst externally the thickening is produced into a tooth-like spine (fig. 3).

The Maxillipedes.—In two examples the inner plate was found to have the spines unusually well developed in addition to the greater length of those at the extreme distal end there were present four spines just below these (fig. 4, *sp.*). The outer palp was considerably longer than usual, and further differed from the normal in the number and length of the spines (fig. 4).

2. Trichoniscus roseus (*Koch*) *Budde-Lund.* (Pl. **20.** fig. 5.)

Forty-eight specimens were examined of this interesting species, but only one variation was observed, which occurred in the maxillipedes of nine out of nineteen specimens collected at Hale, Cheshire. In these (fig. 5) the maxillipedes were of a much more robust type than ordinary, and characterised by three well-defined spines on the outer distal palp, whilst the inner one terminated in a spinous manner as in typical examples of *T. pusillus*, Brandt.

3. Oniscus asellus, *Linn.* (Pl. **20.** figs. 6–16 ; Pl. **21.** figs. 17, 18.)

The oral appendages of one hundred and twelve specimens of this species were examined and thirteen variations were observed. Of these six occurred in the mandibles, three in the first maxillæ, one in the second maxillæ, and three in the maxillipedes. The variations in the form of the mandibles would seem to be endless. The specimens examined were collected from three localities.

The Mandibles.—These are shown in figures 6–11. The first form (fig. 6) occurred in three different specimens, once on the right side and twice on the left. In the general shape this variation differs from the typical form, being produced laterally in a triangular manner. There are three stout mandibular teeth and three smaller pointed teeth partially overlapping these. The second

variation (fig. 7) occurred in four different specimens; twice it was paired and in the other two cases present on the right side only. Here the mandibular teeth appear fused (or worn down ?), whilst below these there is a large, blunt, somewhat hammer-shaped process. The third variation (fig. 8) occurred five times, twice on the left side and three times paired. It is somewhat similar to the previous one (fig. 7), only the teeth are more produced and there is a large blunt spine on the outer face. The fourth variation (fig. 9) occurred in six specimens and paired in only one instance. There are two blunt mandibular teeth and a spinous process on the outer face whose base has coalesced with the lower division, forming a rounded boss. At the junction of the upper and lower processes there is a small palpiform structure bearing setose bristles. The fifth variation (fig. 10) was found twice, occurring once on the right side and once on the left. It differs from any of the others in that the upper process, which normally carries teeth, terminates in a blunt process, and the lower process, which has a notched terminal portion, arises from the inner instead of the outer side. The sixth variation (fig. 11) occurred in two examples and on both sides of the body. Here the lateral border was produced into a blunt flattened process.

The 1st Maxillæ.—Three variations were noted in these appendages (figs. 12–14); with one exception they related to the number and disposition of the spines of both lobes. In one case (fig. 14) only the outer lobe varied. In the first case (fig. 12) the outer lobe was wider than usual and had two large and two small curved spines and three shorter blunter ones, whilst the inner lobe terminated in two broad spines and two much shorter and smaller ones. In the next case (fig. 13) the spines of the outer lobe are the same in number but somewhat differently disposed, and in addition there are two short blunt spines below these on the inner side. The inner lobe terminates in a bifid manner. In the third case (fig. 14) there are six curved spines on the outer lobe and four shorter pointed ones. The inner lobe was normal.

The 2nd Maxillæ.—One variation only was observed (fig. 15), the external distal portion being produced slightly into a tooth-like projection.

The Maxillipedes.—Three variations were noted (figs. 16–18). Those indicated in figures 16 and 17 each occurred twice, and that in fig. 18 three times. That shown in fig. 17 is interesting, exhibiting, as it does, a peculiar flat top of the inner palp with three minute spines, quite distinct from any variation noted in any other species; moreover, I know of no species of Terrestrial Isopod where the palp of the maxillipedes terminates in this manner.

4. Porcellio scaber, *Latr.* (Pl. 21. figs. 19–25.)

Eighty-eight specimens have been examined, and seven variations were noted. One of these occurred four times and another twice in the mandibles, three in the first maxillæ, and two in the maxillipedes.

The Mandibles.—The variation (fig. 19) shows the teeth of the mandible much more pointed than usual and a sharp curved spinous tooth arising from the inside. Four cases were observed where these features were present. Figure 20 shows a further modification where the inner spinous tooth has come to the edge and fused, whilst the true bifid internal tooth is spinous.

The 1st Maxillæ.—The peculiar variation shown in fig. 21 of the inner lobe occurred twice ; it exhibits ten spines at the distal extremity instead of the tiny single spine and the two setose bristles. In a second case (fig. 22) there were four spines at the distal extremity and five smaller ones on the inner margin. A third variation observed once involved both lobes of the maxillæ, the outer lobe terminating distally in two large and one smaller spine, whilst the inner lobe terminated in a dense brush-like mass (fig. 23).

The Maxillipedes.—Two well-defined variations were met with, one (fig. 24) occurring no fewer than eight times and the other (fig. 25) four times. The first is remarkable for the great development of spines both in number and size, whilst in the other case there is a corresponding absence. In both cases the form of the outer lobe approaches that which obtains in normal examples of *Philoscia muscorum* (Scopoli) and again in *Porcellio rathkei*, Brandt.

5. Porcellio lævis, *Latr.* (Pl. **21**. fig. 26.)

Thirty-six specimens were examined, but only one variation was found, which occurred in the 1st maxillæ. The outer lobe terminated in a large, curved spine followed by three smaller ones, then there was a distinct blank space bearing no spines, and below this five much finer spines were present (fig. 26). The inner lobe in all five cases terminated distally in four long curved spines.

6. Porcellionides pruinosus (*Brandt*) *Stebbing.* (Pl. **21**. figs. 27–30.)

Sixty-eight examples were examined of this cosmopolitan species and four variations noted. Three of the specimens were from Northern India, and in all of these the variation shown in fig. 28 was present.

The 1st Maxillæ.—Two well-marked variations occurred, one in two examples (fig. 27) in the spines of the outer lobe, which terminated in a large and prominent spine, with a smaller one arising from the inner side of the plate of the lobe. Below the large spine were six short spines, one below the other. In the second case (fig. 28) the variation was noted in three specimens from Northern India and in another example from the Channel Isles. Here the spines of the outer lobe were well defined, and in all cases there was the smaller spine arising from the inner side of the plate of the lobe. The distal extremity of the inner lobe in all four specimens terminated in a flat plate-like palp (fig. 28).

The 2nd Maxillæ.—In eight specimens from Northern India this appendage had the form shown in figure 29, whilst in six examples obtained from different parts of the British Isles the variation took the form shown in figure 30.

7. Armadillidium vulgare (*Latr.*) *Milne-Edwards.* (Pl. 21. figs. 31–33.)

Fifty-one examples of this species were examined and three variations observed, viz., one in the mandibles found twice, and one in each of the maxillæ, each of which occurred three times.

The Mandibles.—A slight modification was noticed in two specimens where the teeth were shorter than usual (fig. 31).

The 1st Maxillæ.—The outer lobe terminated in a strong spine, rather shorter, however, than in typical examples, and this was followed by five very short, tooth-like spines ; the inner lobe terminated in a sharp, short spine on the outer side and two small blunt spines on the inner side (fig. 32).

The 2nd Maxillæ. In the typical form the terminal portion externally is produced into a tooth-like piece whilst internally the terminal portion is more or less flat or plate-like. Sars's figure (5, pl. 82, fig. *m*) is an excellent one. In the variation noted in three examples, both the internal and external terminal portions were flat and rather stouter in build.

III. Summary and Conclusion.

1. Four-hundred and thirty-eight specimens have been examined embracing seven species referable to six genera and four families, and one-hundred and ten individuals exhibited variations.

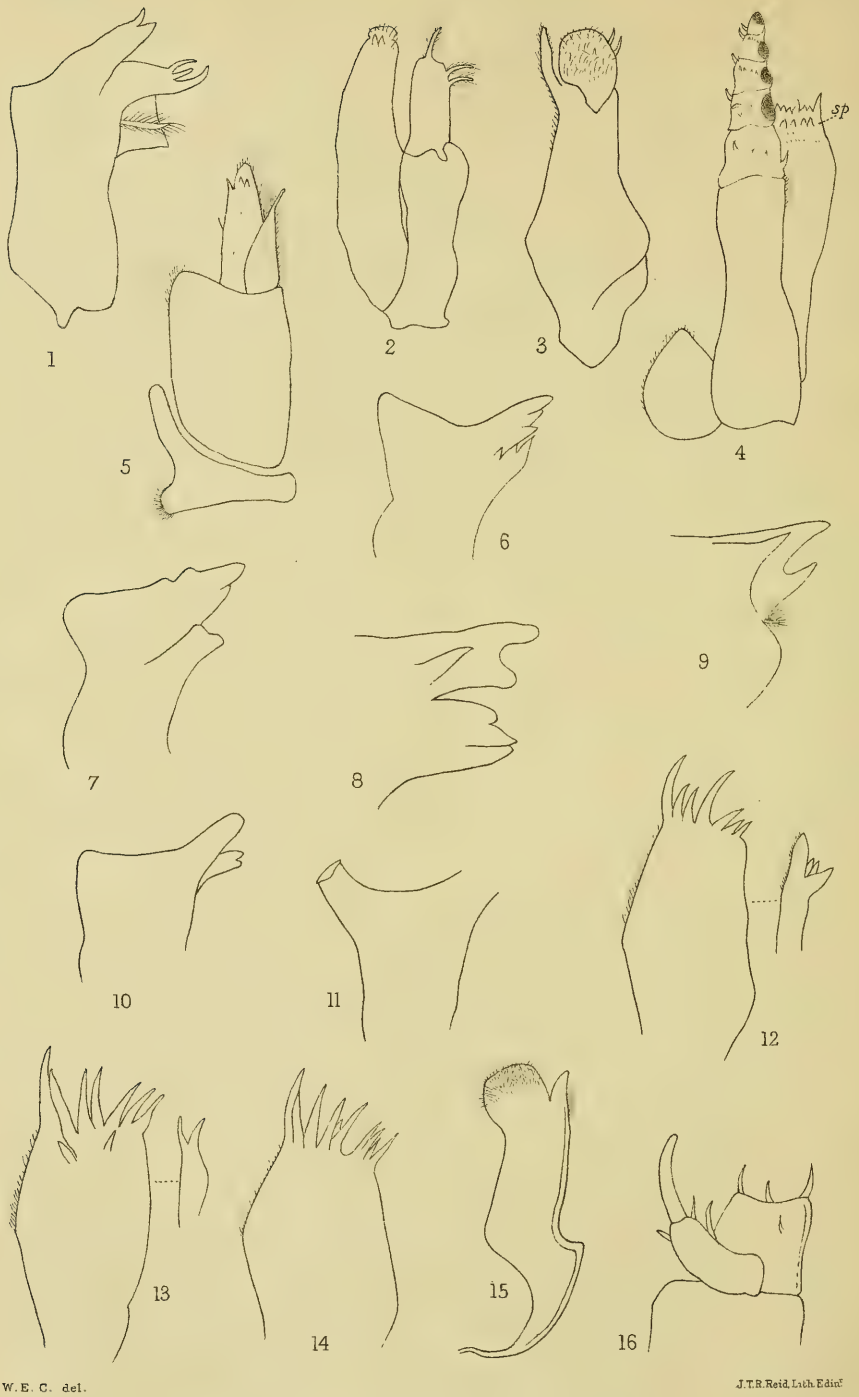
2. Of the one-hundred and ten individual variations thirty-one occurred in the form of the mandibles, twenty-eight in that of the 1st maxillæ, twenty-one in that of the 2nd maxillæ, and thirty in the form of the maxillipedes.

3. The conclusion arrived at, after carefully examining and considering the above mentioned variations, is, that the oral appendages are subject to a considerable amount of variation, and for purposes of specific distinction are not of the value generally supposed, and certainly not so constant as the form of the head, the mesosomatic segments, the antennæ, the telson, uropoda, and thoracic appendages. That they may serve to characterise the larger divisions is possible.

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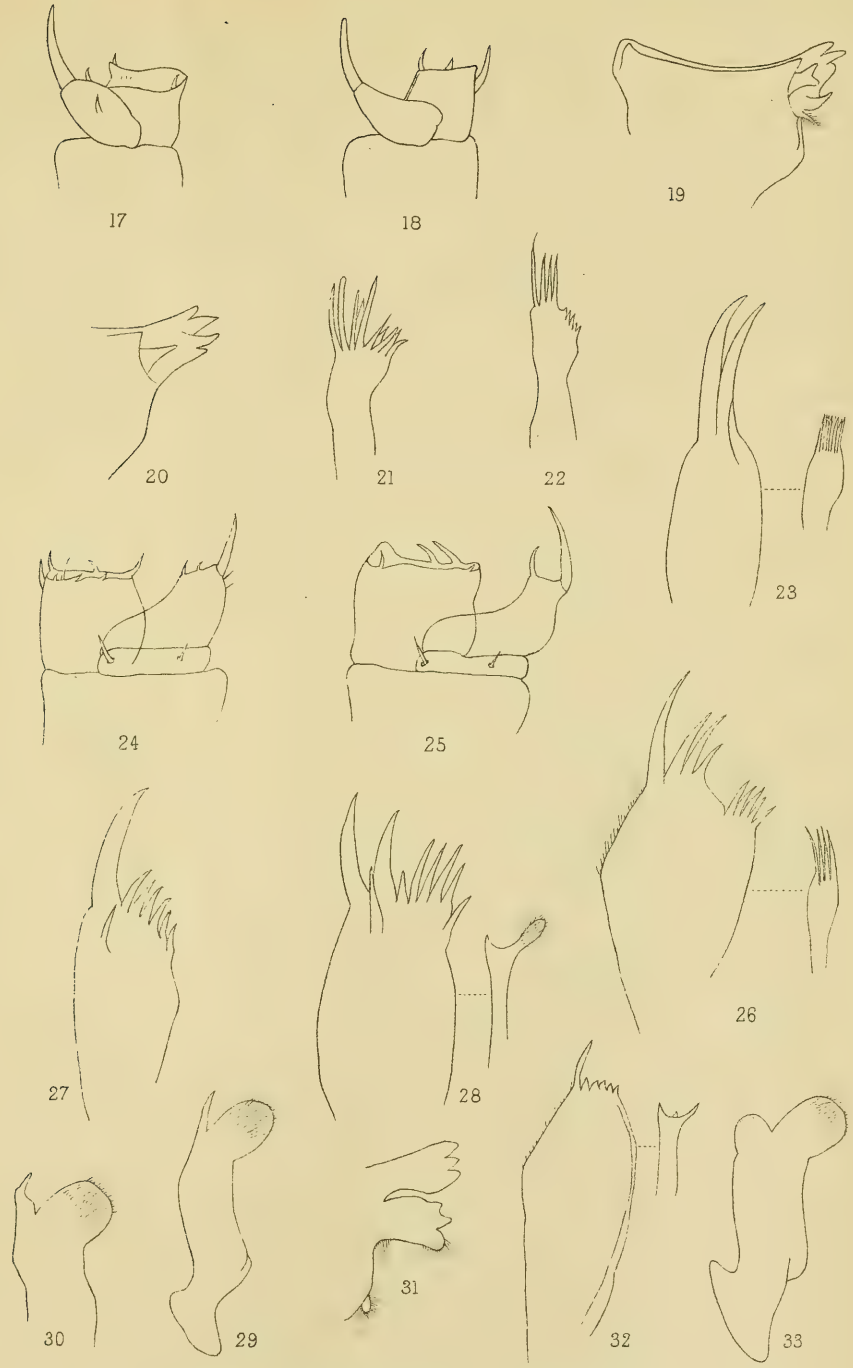
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W. E. C. del. J. T. R. Reid, Lith. Edinr.

ORAL APPENDAGES OF ISOPODA.



W E C del. J.T.R. Reid Lith. Edin.

ORAL APPENDAGES OF ISOPODA.

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EXPLANATION OF THE PLATES.

Plate 20.

Fig.	1. *Ligia oceanica*, Linn.	Mandible.
Fig.	2. „ „	1st Maxilla.
Fig.	3. „ „	2nd Maxilla.
Fig.	4. „ „	Maxillipede.
Fig.	5. *Trichoniscus roseus* (Koch).	Maxillipede.
Figs.	6–11. *Oniscus asellus*, Linn.	Mandibles.
Figs.	12–14. „ „	1st Maxillæ.
Fig.	15. „ „	2nd Maxilla.
Fig.	16. „ „	Maxillipede.

Plate 21.

Figs.	17, 18. *Oniscus asellus*, Linn.	Maxillipedes.
Figs.	19–20. *Porcellio scaber*, Latr.	Mandibles.
Figs.	21–23. „ „	1st Maxillæ.
Figs.	24–25. „ „	Maxillipedes.
Fig.	26. *Porcellio lævis*, Latr.	1st Maxilla.
Figs.	27, 28. *Porcellionides pruinosus* (Brandt).	1st Maxillæ.
Figs.	29, 30. „ „	2nd Maxillæ.
Fig.	31. *Armadillidium vulgare* (Latr.).	Mandible.
Fig.	32. „ „	1st Maxilla.
Fig	33. „ „	2nd Maxilla.

Some Observations on the Tentacles of *Blennius gattorugine*.

By H. A. Baylis, B.A., of Jesus College, Oxford. (Communicated by Prof. G. C. Bourne, F.R.S., Sec.L.S.)

(Plates 22 & 23, and 1 Text-figure.)

[Read 15th January, 1914.]

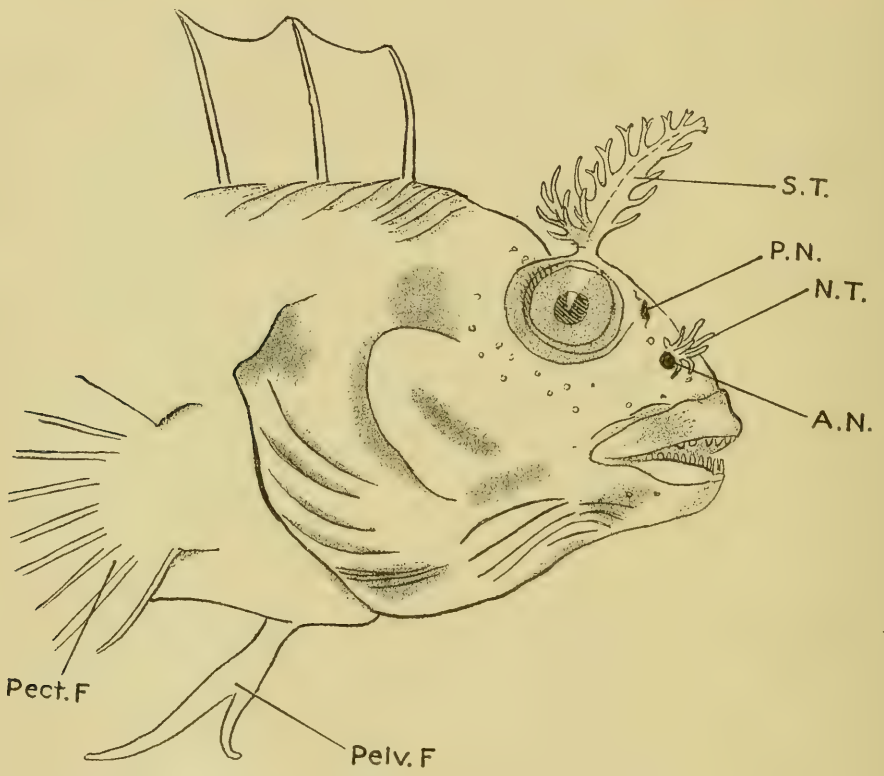
While examining the cutaneous sense-organs of the barbels and other appendages of various fishes at Naples, it occurred to me that the tentacles of this remarkable species might provide some facts of interest; and though previous observers have not, so far as I have been able to discover, noted any peculiar sense-organs in these appendages, I did not feel satisfied that tentacles of such peculiar shape and appearance could have become a characteristic feature of the species without performing some special function. My investigations have not made it clear what that function actually is, but it does appear to me that sense-organs of at least one kind are present, and this is my excuse for publishing the following remarks.

The head of *Blennius gattorugine* bears two pairs of branched appendages (see text-figure). The larger pair, situated on the top of the cranium, immediately above the eyes, may be called the supraorbital tentacles. It is with these that my account is chiefly concerned. The smaller pair are situated on the posterior edge of the somewhat tubular anterior nostrils, forming a kind of fringe of filaments overhanging the nostril on either side.

As far back as 1872 M. Jobert [2] published an account of the general structure of the large tentacles, from a study of transverse sections, as well as a general description of their form. I need therefore only remark, as to their shape, that they consist of a slightly tapering stem, flattened laterally, with numerous smaller branches, or "filaments ascendants," as M. Jobert calls them, along its anterior and posterior edges. The branches, in their turn, often give off still smaller twigs, especially those nearest to the base of the tentacle and posterior to it. M. Jobert mentions that the tentacles were about 2 cm. in length in the specimen examined by him, but in those which I have studied they are considerably smaller (about 11–12 mm.).

When the fish is in water, the tentacles stand up vertically, apparently rigid, looking like a pair of elaborately branched antlers. M. Jobert states that "au centre se trouve une sorte de charpente de tissu conjonctif très-dense, qui permet de les maintenir, même hors de l'eau, à l'état de demi-érection." This may be the case in very fully developed specimens, but I find that in mine the tentacles are limp, and lie down flat on the head when the animal is taken out of water.

The tentacles are capable of a certain amount of motion, but are not supplied with special muscles, and move, I think, only in correspondence with the movements of the eyes. If an object, such as a glass rod, is made to approach the head of a normal Blenny, the tentacle on the side nearest to it may sometimes be seen to move slightly away from it, but at the same time the eye is turned upwards to examine the intruding object, and the motion of the tentacle does not appear to take place in specimens which have been



Head of *Blennius gattorugine*. × 2.

A.N., anterior nostril. N.T., nasal tentacle. Pect. F., pectoral fin. Pelv. F., pelvic fin. P.N., posterior nostril. S.T., supraorbital tentacle.

blinded by cutting the optic nerves. The significance of this fact will be seen later, in inquiring into the possible function of the tentacles.

When cut off, the tentacles appear to be readily regenerated. In this species the regenerated parts show signs of branching while still very small; the pigment is at first very scanty. This is in curious contrast to the process in *B. ocellaris*, in which the regenerated parts remain unbranched for a long time, though attaining a considerable size, and being quite deeply pigmented.

Microscopic Structure.

In sections, either transverse or longitudinal, the centre of the tentacle is seen to be occupied by numerous bundles of medullated nerve-fibres, which, as M. Jobert has shown, are offshoots from the supra-ophthalmic branch of the Vth nerve. These bundles are accompanied by small blood-vessels, which run parallel to them, and in some cases even appear to be partly surrounded by them. Branches are sent off from this central and very abundant nerve-supply to the various lateral twigs of the tentacle. These nerves and vessels are surrounded by a connective-tissue sheath, and this is succeeded by a more or less dense network of fine connective-tissue fibres, with nucleated cells interspersed. Peripherally there is a dense corium, here and there raised into a small papilla. The outer part of the corium shows a stratified structure, as M. Jobert points out. Internally, however, the corium takes the form of a series of vertically-placed bundles of very fine fibres. In transverse sections the centres of these bundles sometimes give the appearance almost of a little "lens"—probably a mass of some refractive colloid substance (Pl. 22. fig. 2). These vertical bundles give the corium, in a transverse section, the appearance of being divided into a series of nearly regular blocks; immediately below these there is a layer of very large, branched pigment-cells, densely crowded with granules of pigment, which may be of various colours—yellow, reddish, or nearly black. These cells send their amœboid processes up between the "blocks" of the corium, and it is at this level that the pigment granules are usually most densely crowded (fig. 2).

Starting from the corium externally to the pigment-cells, and passing inwards between them at frequent intervals, at right angles to the longitudinal axis of the tentacle, are seen bundles of connective-tissue strands, which stain deeply with nigrosin. They appear to lose themselves at one end in the corium, and at the other in the connective-tissue sheath of the central nerve-bundles. I was at first led to think that they might be nerve-sheaths, but have not been able to demonstrate nerve-fibres running through them, and must therefore suppose that they are merely strengthening and supporting structures, helping to render the tentacle more or less rigid. These structures are much more numerous and conspicuous in *B. ocellaris* than in the species under consideration. Their arrangement is indicated in fig. 1.

No doubt the ultimate branches of the nerves lose themselves in a fine network immediately below the pigment layer of the corium. In my preparations, however, it is difficult to distinguish the fibres belonging to this system from those of the ubiquitous connective tissue. My attempts to stain with methylene-blue and with nitrate of silver were signal failures, and

though chloride of gold gave useful results in one particular, as I hope to show, yet for this purpose it was equally unsuccessful.

It now remains to describe the structure of the epidermis, and it is chiefly here that my account, I believe, differs from those previously given. M. Jobert was unable to study the epidermis, as it was lacking in the specimen used by him, owing to imperfect fixation. He mentions, however, that on the stem and branches of the tentacle dermal papillæ are present, exactly like those of the barbels of other species, in which they are usually surmounted by taste-buds in the epidermis. One might, therefore, expect to find a taste-bud in this instance wherever there is a papilla. This, however, does not seem to be the case. A. Zincone [5] gives some account of the cellular elements of the epidermis, and a figure of a transverse section of the tentacle. He does not mention the presence of any taste-buds, either on dermal papillæ or anywhere else ; but he mentions certain other kinds of cells, to which I shall have occasion to refer later. His figure is rather diagrammatic, and seems to differ somewhat from his description. He does not show, for instance, the "rilievi papillari notevoli" of the dermis ; nor any peculiar cells in the epidermis except ordinary mucous cells. Bateson [1] states that he found *no* sense-organs on the "tree-shaped processes standing up from the anterior nostril and orbit of *B. gattorugine*."

Now, it seems to be tolerably clear that the dermal papillæ are not the seat of taste-buds in this case. At the same time, I have noticed in a few of my sections, both in this species and in *B. ocellaris*, little groups of elongated cells extending through the thickness of the epidermis, and having very much the appearance of taste-buds. They do not seem to be arranged on any definite plan, and in fact are so rare that they have the appearance of having "strayed" from a more normal situation. Where they do occur, they always appear between, and not on, the dermal papillæ. In fig. 3 is represented such a group of cells from a tentacle of *B. ocellaris*. The arrangement of the cells in this case seems so definite that I have figured it for comparison with the less convincing example from *B. gattorugine* shown in fig. 4 (Pl. 23). The cells composing these groups do not, it is true, seem quite similar to those of ordinary taste-buds, and they are few in number. But the fact of such groups of cells occurring at all, and of their extending from the basement membrane to an apparently free ending at the surface, is in itself worthy of notice. Unfortunately I have not been able to see whether any nerve-fibres pass to these groups of cells, but it seems probable that such is the case, and that they are sense-organs of some kind, and very possibly true taste-buds.

These, however, are not the only sense-organs which I believe to exist in these appendages. In sections of the tips of the branches, stained with chloride of gold, I have found a great abundance of peculiar elongated cells running through the thickness of the epidermis, and ending distally in

a fine though blunt-ended hair-like process. They closely resemble olfactory cells in general appearance, having a rather swollen inner end, containing a comparatively large nucleus. Distally they taper gradually, but appear to end abruptly, while proximally I believe they are connected with fine nerve-fibres. These cells are invisible in preparations stained by ordinary methods, but stain deeply with the gold chloride, with the exception of their nuclei, while the surrounding tissues remain vaguely defined. Fig. 5 gives a general idea of their appearance, while fig. 6 is a drawing of a few of them at a higher magnification, showing how the fine nerve-fibres appear to come into connection with them. These fibres I have been unable to trace through the corium, owing to the dense pigment. On dissolving the pigment by means of Mayer's chlorine bleaching method, the tissues will no longer stain properly. Hence I can only conjecture (and it seems a reasonable hypothesis) that nerve-fibres pass from the network beneath the corium, through the latter, to reach these fusiform cells in the epidermis. In order to establish the existence of these cells more certainly, I have made preparations of them in glycerine by macerating the tentacles with weak alcohol, and also with osmic acid. I hoped also in this way to be able to see more clearly their connection with the nerves, but in this I was disappointed. Fig. 7 is a composite group of a number of these elongated cells, isolated in this way. This method seems to leave little doubt that such cells actually exist as component parts of the epithelium. They are exceedingly numerous, occurring singly among the ordinary cells of the epidermis, and not forming groups as taste-buds. They only occur near the tips of the fine branches, and not on the main stem of the tentacle. This might, perhaps, account for their having been hitherto overlooked.

It is interesting to notice, however, that Zincone, in the paper already cited, has given an account and a figure of certain elongated cells, which he calls "cellule fusiformi," in the epidermis of the free fin-rays of *Trigla*. These cells are connected with nerve-fibres passing through the dermis. He says, "Lo strato epidermoidale riposa sopra una zona di connettivo omogeneo irto di processi papilliformi. Le cellule fusiformi a due poli fanno continuazione non interotta con le papille, e probabilmente raggiungono la cuticola." His figure shows one of these cells with its nerve, but the "probable" connection with the cuticle is only represented by a dotted line. It will readily be seen that these cells have a certain resemblance to the elongated cells in *Blennius*; but to what extent they are homologous (or analogous) with them is doubtful.

Cells somewhat similar in appearance are also described and figured by Morrill [6] from the free fin-rays of *Prionotus*, another member of the Gurnard family. He appears to have satisfied himself that they are tactile in function, and used in finding food.

I find fusiform cells also in the nasal tentacles of *B. gattorugine*, in sections

of the filaments stained with gold chloride. The cells appear to be exactly similar to those in the supra-orbital tentacles, and are equally invisible by other staining methods.

Before leaving the morphological characters of the epidermis, certain other kinds of cells must be mentioned which occur with great frequency among the ordinary stratified epithelium. Zincone mentions two kinds—namely (1) ordinary unicellular mucous glands ("cellule a forma di bottiglia"), which have their narrow ends on a level with the outer surface of the epithelium. His account of these agrees with my observations. As he says, they are not stained by osmic acid or by chloride of gold, but remain as clear, conspicuous, refractive bodies. They have a small nucleus at the bottom of the cell, surrounded by a thin protoplasmic residuum. The greater part of the cell is occupied by the mucous secretion. These are the only cells, apart from the ordinary epithelial cells, shown in his figure. They are particularly abundant near the base of the tentacles. Some of them are shown in outline in my figure 8, and one from *B. ocellaris* in fig. 9 *a*. (2) If I understand him aright, the only other cells alluded to by him are round or oval cells, more deeply imbedded in the epidermis, and staining deeply both with osmic acid and chloride of gold. He says: "Vi sono invece altre cellule di grandezza parimenti notevole, le quali benchè non presentano la forma dei cosi detti *Kolben* descritti dal Max Schultze e Fr. E. Schulze, ed invece si presentano di una forma ovale, pure subiscono una reazione particolare non commune alle cellule a muco, si colorano cioè fortemente al cloruro d'oro ed all' acido iperosmico." As he suggests, they are probably merely an early stage of the mucous cells, and would later migrate to the surface and acquire the characteristic flask-like shape, with an opening on the exterior. As in their final form, they have an eccentric nucleus surrounded by a little residual protoplasm, and the rest of the globular cell is swollen out with the secreted matter, which becomes deep black when treated with osmic acid. With ordinary methods of staining, such as borax-carmine, these cells remain clear. A typical example of such a cell is shown in fig. 9 (*M*). See also figs. 2 and 4 (*M*). Two such cells, treated with osmic acid and isolated, are also shown in fig. 10.

In addition to these two forms of mucous cells, it seems to me that there are also present still more conspicuous cells, which may fairly be compared with the "Kolben" described and figured, especially for *Petromyzon*, by F. E. Schulze [4]. These are very large elongated cells, extending, as a rule, through the whole thickness of the epidermis. In sections they always appear to lie in a space hollowed out in the ordinary stratified epithelium; an appearance which may, perhaps, be due to shrinkage. As Schulze says, there is no apparent membrane surrounding these cells, and they appear to be of a semi-fluid consistency ("dickflüssige Consistenz"); but after hardening, they can easily be isolated by teasing or pressure, and then appear as

bodies of a fairly constant, somewhat bottle-shaped form. The mass of the cell appears to be composed of fine, highly refractive granules; it stains rather deeply with carmine, and appears uniformly greyish after treatment with osmic acid. In the centre of this granular mass there is a large nucleus, which often appears to consist of two halves very closely apposed. This peculiarity does not, however, appear to be constant. The double nucleus may be seen in my figures 2 (A, *n'*) and 9 (A). At the outer end of the cell there is always a little clear, cup-shaped hollow, which in my preparations always seems to be open to the exterior [fig. 10 (*c.*) and 9 (*o.*)]. According to Schulze, this hollow, in the "Kolben" of *Petromyzon*, varies considerably in size and position. In some cases he found it as a mere space in the cell, with no external opening. In others it not only had an opening at the outer extremity of the cell, but might even extend inwards as an elongated tubular cavity, tapering to a point towards its proximal end. This appearance I have never observed in my preparations. Schulze is of opinion that the form with closed cavity is an early stage, and that the cavity afterwards acquires an opening and pours a secretion out on the surface of the skin. He finds fat-globules sometimes present in the cavity, but does not seem certain whether these may not be pathological. According to M. Schultze [3] (as quoted by Schulze), the "Kolben" of *Petromyzon* often appear to be in close connection with perpendicular strands of connective tissue immediately below the cutis, and these strands often contain a dark fibre which may possibly be a nerve-fibre. He also finds, as does F. E. Schulze, that the Kolben themselves show certain cross-striations, caused by alternate layers of doubly and singly refractive substance, comparable to the appearance of striated muscles.

M. Schultze therefore draws the conclusion that the Kolben are probably "nervöse Endapparate muskulöser Natur."

F. E. Schulze, however, points out that neither the cross-striations nor the intimate connection with the cutis are constant for all fishes in which "Kolben" are found. In *Petromyzon fluviatilis* and the Eel, he says, all the "Kolben" stand on the cutis; but in other fishes examined by him (*Silurus*, *Cobitis*, *Tinca*, and *Leuciscus*) they may occur at all levels in the epidermis and separate from the cutis. Even in another species of Lamprey, described by H. Müller, both these peculiarities of the "Kolben" are absent. Schulze therefore remains undecided as to the nature of these cells, but thinks they are perhaps comparable with the sebaceous glands of mammals, their substance breaking down to form fatty matter, which is discharged as a secretion on the surface of the skin. He thinks that normally the "Kolben" migrate to the surface to perform this function; in *Petromyzon* and the Eel, where they never lose their connection with the cutis and have no actual opening on the exterior, their secretion probably finds its way out between the outer cells of the epidermis. He is also of the opinion that their apparent muscular structure may be for the expulsion of the secretion.

In most particulars the "Kolben," if I may so call them, of the tentacles of *Blennius* agree closely with those of *Petromyzon*; but they nearly always appear to have an opening on the exterior between the outer layer of epidermal cells. I have not observed cross-striations or fat-globules in them, but the double nucleus and the clear cavity are almost always visible. The latter, however, is always open and of a cup-like shape. The "Kolben" usually either touch the cutis at their lower ends, or are only separated from it by protoplasmic processes from the surrounding cells, rarely by any complete cells with nuclei. (Of course, an appearance of this kind may be produced in sections which do not pass quite through the longitudinal axis of the "Kolben.") I have not been able to discover any nerve-fibres in connection with them, and do not think that they ever form any connection with my vertical connective-tissue "blocks."

As regards the function of the tentacles, and especially of the peculiar cells previously described, which seem to me to be undoubtedly sensory, I am not in a position to make any definite statement. Apart from morphological considerations, which would lead one to suppose that these cells might be olfactory in function, the only means of investigating this question is the experimental method. There are, however, great difficulties in the way of reaching any certain conclusions by this means. Thus, even if one could prove that the fish recognized the presence of food or of chemical substances by the use of their tentacles, by cutting off all other avenues of perception, it would be well-nigh impossible to say whether the sensation appreciated was one of smell, of taste, or of what G. H. Parker, in a recent paper, has termed the "common chemical sense." The few experiments which I have made in this direction are not of much value for this reason. I tested a few normal specimens first with certain reagents, with a view to finding out whether the tentacles were sensitive to them. In each case a small pellet of wool was dipped in the reagent, and then (first) held over or near the tentacles in the water, and (secondly) lightly brushed against them. To oil of cloves there was no perceptible reaction. Acetic acid caused a rapid retreat on the part of the fish; they backed away as soon as the diffusing acid reached them, and without being touched by the pellet. But the movements of the mouth and opercula showed that some of the acid had got into the mouth. Hydrochloric acid produced similar results. Caustic soda seemed to have a decided effect when placed near the tentacles, the fish darting away at once. When some of the white precipitate formed entered the mouth, the fish backed a little and spat it out, but did not dart away. Caustic ammonia did not produce any marked effect when presented to the tentacles, but the fish did not seem to like it when presented in front of their snouts. Now it cannot be shown from these experiments that the reactions may not have been due to the stimulation of the free nerve-endings in the skin of the head, or of taste-buds situated either in the mouth or elsewhere. There is no proof that any of the reactions were due to the stimulation of organs in the tentacles alone.

As a further test, three specimens were etherized, and in two of them the optic nerve on either side, and the olfactory tracts, were cut. In the third the olfactory tracts only were severed. These specimens still reacted to chemical agents, such as acetic acid, as might be expected, but this fact is of no value. Their tentacles were very sensitive to touch, especially in those whose optic nerves had been cut. After a rest of some four days, to allow of recovery from the effects of the operation, the three fishes were placed in a small aquarium and tested with worms and pieces of worms. The two which had been blinded showed no sign of noticing the food when placed on the bottom of the vessel near their snouts or eyes. The unblinded specimen showed signs, as might be expected, of perceiving them by sight. When pieces were lightly brushed against their tentacles, all three specimens at first backed away, as if reacting to an ordinary touch-stimulus. One of the blinded individuals, however, appeared to recognize the presence of food. He made a feeble snap at it, but did not swallow it. In fact, none of them fed at all. After two or three trials they ceased to react at all to the stimulus of touch applied to the tentacles. As a control, three normal specimens were fed in the same vessel, two of which fed readily. On the two following days the same procedure was gone through, with similar results. I am inclined to believe that in the one fish which seemed to recognize food the olfactory function may not have been completely destroyed.

The only conclusions with regard to the tentacles which it is possible to deduce from the above meagre evidence are :—

(1) That the tentacles are very sensitive to touch.
(2) That they *may* recognize the "feel" (? the taste or odour) of the substance that touches them. This, however, is very doubtful.

As to the normal function of the tentacles, therefore, I am still undecided. The only fact which seems tolerably certain is that they contain *some* nervous apparatus which is eminently sensitive to touch, whether the stimulus comes from an article of food or an inanimate object. Thus, normal specimens whose tentacles are lightly touched with a glass rod as they lie on the bottom of an aquarium, will lean over in an almost ludicrous manner away from the side touched, at the same time moving their eyes to see the source of irritation. Whether my fusiform cells play any part in the perception of this kind of stimulus is a question which I must leave unanswered.

It would have been interesting if it could have been shown that the tentacles were sensitive to disturbances or vibrations in the water, due to the movements of other animals or to deliberate stirring by artificial means. From the habit shown by these fishes of lying half concealed among rocks and stones, often with only the head exposed and the tentacles erect, this would almost seem a likely function. I have not, however, been able to find

any evidence that such is the case *. Of course, there is always the possibility that such appendages may serve merely to increase the resemblance of the animal to its surroundings by simulating bits of seaweed and the like, or by merely breaking the continuity of its outline, as is no doubt the case among various fishes, such as *Scorpæna*. But this offers no explanation of the presence of special sense-organs in the tentacles, and could not, therefore, in this case be considered the sole justification for their existence.

Note.—In *Blennius ocellaris* somewhat similar supraorbital tentacles are found, but they are more flattened in shape, with expanded extremities. They do not appear to contain any fusiform cells, though in other respects their histology closely resembles that of the tentacles of *B. gattorugine*. There are no nasal tentacles, but there is a small flattened dermal appendage on the back, on either side of the first or anterior ray of the dorsal fin. In sections of these appendages no fusiform cells or taste-buds were found, but there are a very few "Kolben" and numerous globular mucous cells. The corium is very thick, and consists of fine fibres arranged in a conspicuously concentric manner, with large vertical bundles internally. The connective tissue in the centre of the organ is rather loose, with a few small nerve-bundles running longitudinally through it.

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* Mr. C. Tate Regan, of the British Museum, has suggested to me that these tentacles might serve to gauge the amount of space in the crannies of rocks such as these fishes love—much as the whiskers of cats, to quote a familiar case, are supposed to gauge spaces through which they creep.

EXPLANATION OF THE PLATES.

Plate 22.

Fig. 1. A transverse section of the main stem of a tentacle of *Blennius gattorugine*; low power. Partly diagrammatic.

a, One of the "Kolben." *b*, blood-vessels. *C.*, corium. *C.T.*, the deeper connective tissue. *Ep.*, epidermis. *F.*, one of the radially-disposed bundles of connective-tissue fibres. *m.*, mucous cells (round form). *N.*, nerve-bundles. *P.*, pigment. *Pa.*, dermal papillæ.

Fig. 2. A small portion of the edge of a transverse section of the same.

A, "Kolbe." *C.*, the outer layer of columnar epithelium. *Co.*, corium. *L.*, "lens-like" body in perpendicular column of connective tissue. *M.*, round form of mucous cell. *P.*, pigment-cell. *n.*, nucleus of pigment-cell. *n.'*, double nucleus of Kolbe. Cam., oil imm. $\frac{1}{12}''$, oc. ×8.

Fig. 3. *Blennius ocellaris.* Small portion of the skin of the tentacle in longitudinal section.

C., Stratified outer part of corium. *Cu.*, cuticle. *Ep.*, epidermis. *T.*, group of elongated cells, possibly a taste-bud. Cam., oil imm. $\frac{1}{12}''$, oc. ×8.

Plate 23.

Fig. 4. *Blennius gattorugine.* Portion of transverse section of the stem of a tentacle.

T., A group of elongated cells (taste-bud ?). Other letters as in fig. 2. Cam., oil-imm. $\frac{1}{12}''$., oc. ×8.

Fig. 5. *Blennius gattorugine.* Part of the edge of a transverse section of one of the "twigs" of a tentacle, stained with gold chloride.

C., Corium. *C.T.*, connective-tissue and nerve-fibres. *E.*, end-cell. *Ep.*, epidermis. *h.*, hair-like termination of end-cell. *n.*, nerve-fibres. *P.*, pigment. Cam., oil-imm. $\frac{1}{12}''$, oc. ×5.

Fig. 6. Portion of a similar section, more highly magnified.

Lettering as in fig. 5. *E.'*, end-cells cut obliquely or to one side.

Fig. 7. Isolated elements of the epithelium of the tentacle of *B. gattorugine.*

(Macerated in weak alcohol, stained with picrocarmine, and examined in glycerine.)

E., End-cells. *Ep.*, ordinary epiderm-cells. *E.'*, an end-cell with bifurcated base. *d.*, distal extremity of end-cell. *n.*, proximal end, with minute nerve-fibre. *n'.*, nucleolus. Cam., obj. $\frac{1}{6}''$, oc. ×8.

Fig. 8. *B. gattorugine.* Part of a longitudinal section near the base of a tentacle prepared with osmic acid.

a, clear flask-shaped mucous cells, occurring only near the base. *b*, round form of mucous cells, blackened with osmic acid. Other lettering as before. Obj. $\frac{1}{6}''$, oc. × 5.

Fig. 9. *B. gattorugine.* Portion of transverse section of a tentacle.

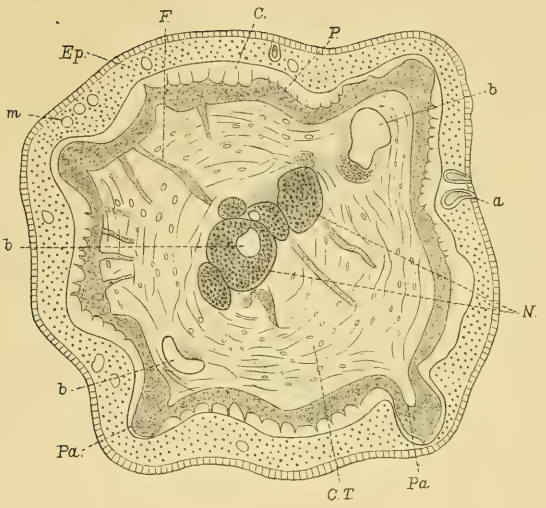
A, "Kolbe," in median section. A', another, cut to one side. *M.*, round form of mucous cell. *o.*, opening of the cavity of the "Kolbe." Other letters as in previous figures. Cam., oil-imm. $\frac{1}{12}''$, oc. × 5.

Fig. 9 *a*. *Blennius ocellaris*. Part of transverse section of tentacle.

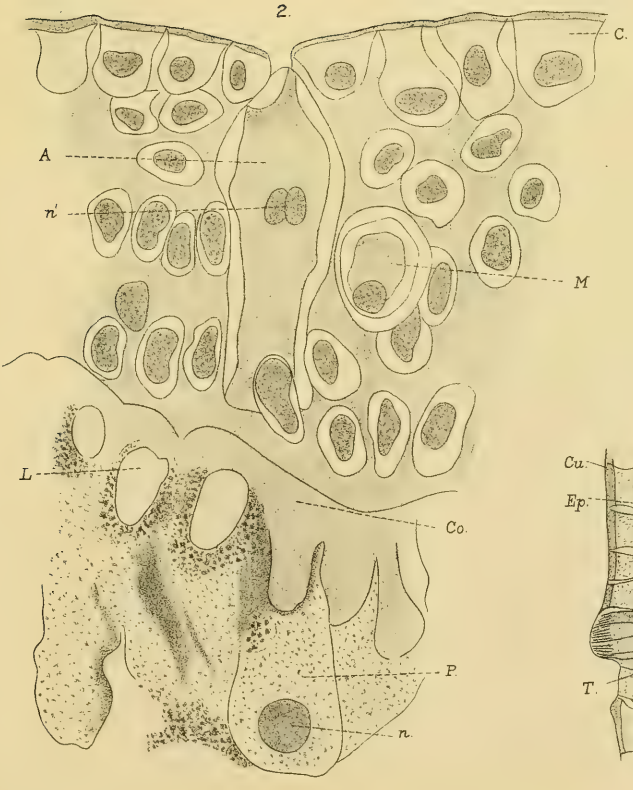
M., a flask-shaped mucous cell. *n.*, its nucleus surrounded by the residual protoplasm. Other lettering as before. Cam., oil-imm. $\frac{1}{12}''$, oc. × 8.

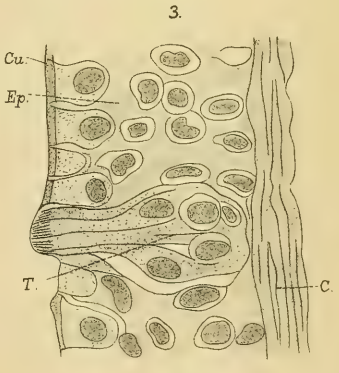
Fig. 10. *B. gattorugine*. Isolated elements from the epidermis of the tentacle, treated with osmic acid.

A, "Kolben." B, round form of mucous cell, blackened with osmic acid. *c.*, cup-like cavity of Kolben. *n.*, eccentric nucleus of mucous cell. Cam. obj. $\frac{1}{6}''$, oc. × 8.



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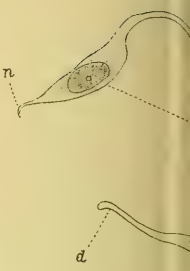
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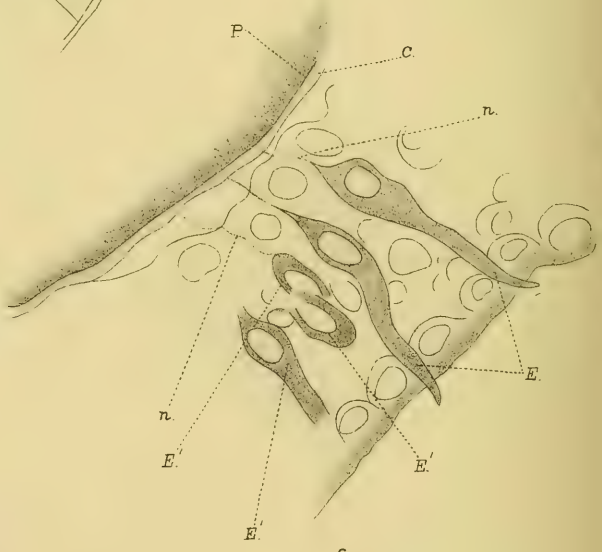
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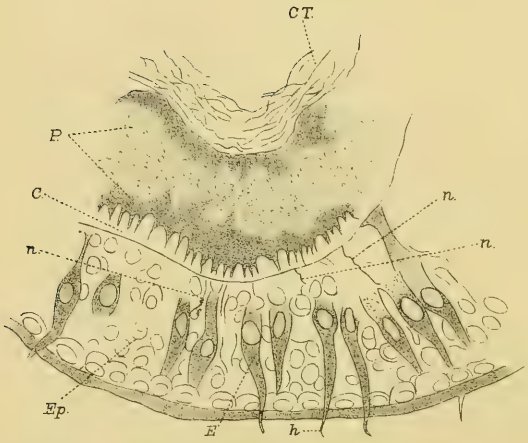


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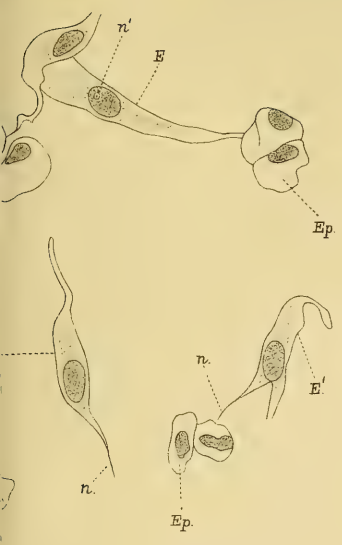


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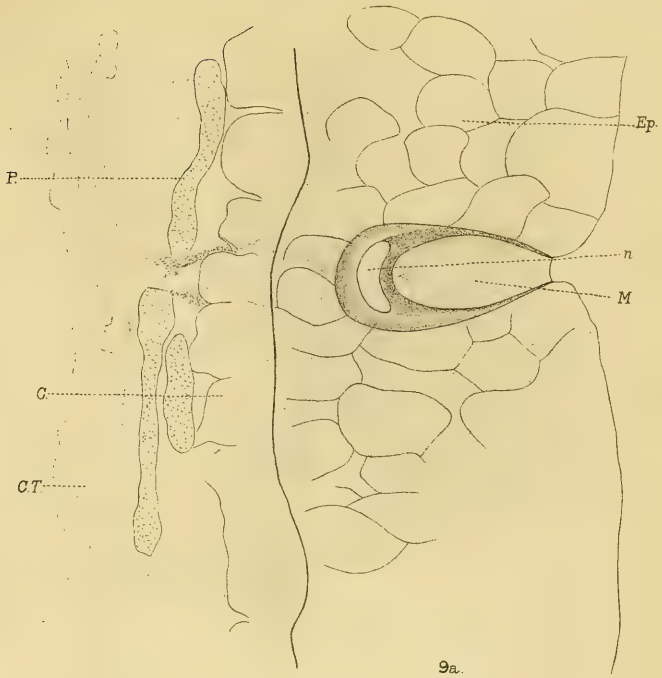


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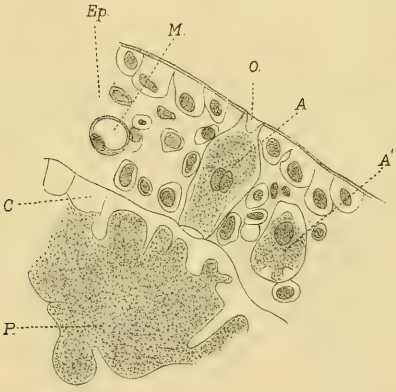
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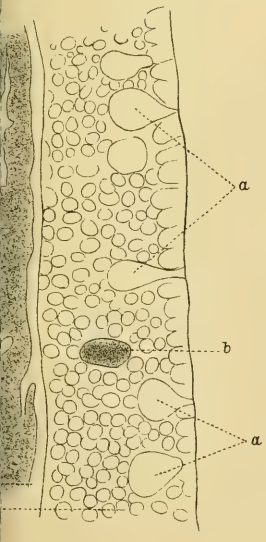
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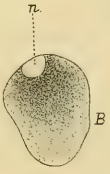
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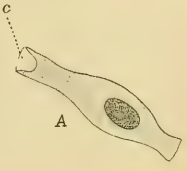












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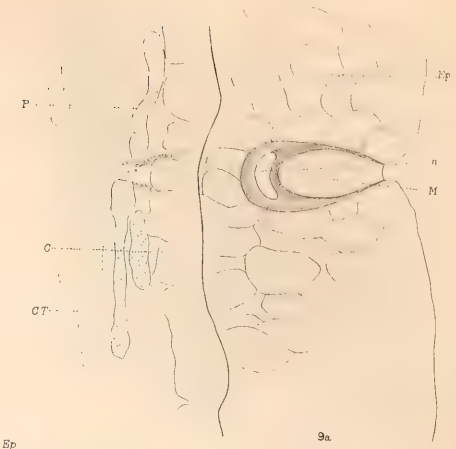
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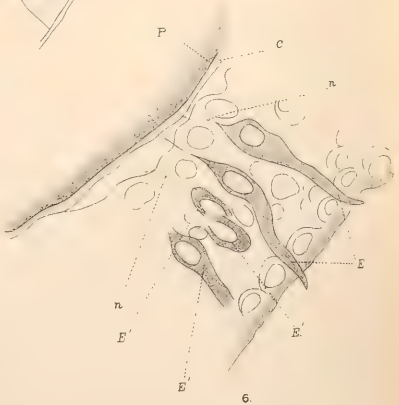
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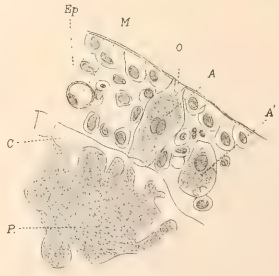
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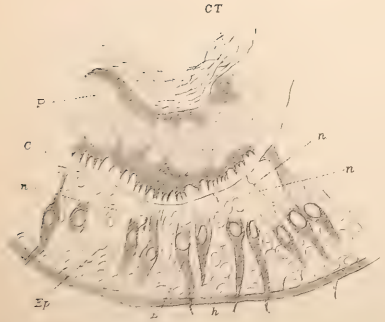
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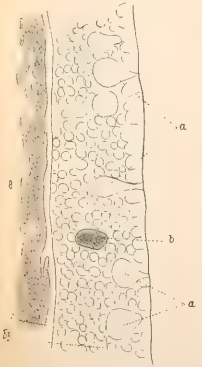
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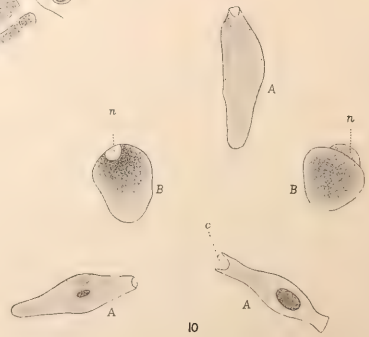


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On the Mouth-Parts and Mechanism of Suction in *Schizoneura lanigera*, Hausmann.

By J. Davidson, M.Sc., F.E.S. (Communicated by Dr. A. D. Imms, F.L.S.)

(Plates 24 & 25, and 2 Text-figures.)

[Read 5th February, 1914.]

I. Introductory Remarks.

Owing to the great importance of the family Aphididæ from the point of view of Economic Entomology, it is thought that a detailed investigation of the structure and mechanism of the mouth-parts and associated structures in a member of this family, may be of considerable help in elucidating many points in connection with the life-history and habits of these insects.

There are many questions associated with the mechanism of suction in Aphids, about which our knowledge is very obscure. The action of the stylets in the plant tissues is by no means clearly understood, although Büsgen (1890) contributed a great deal to our knowledge of this problem.

When considering the influence of the sap of certain plants upon the development and reproduction of Aphids, it is very essential to know exactly from which cells the necessary food is derived. There is moreover the question as to why certain species of Aphids produce galls on the host plants, as is the case with the species under consideration.

From observations made in connection with some experiments I have carried out this summer, it seems evident that these insects are susceptible to changing conditions of growth of the host plant. The present paper has been written in the hope that it may be helpful in the further investigations of the problems mentioned above. It deals only with the anatomy of the mouth-parts and associated structures, and attempts to give a clear account of the way in which the plant juices are conveyed into the pharynx and then passed through the œsophagus into the stomach, and further to explain how the secretion from the salivary glands is forced by the salivary pump into the tissues of the host plant.

This work has been carried out in the zoological laboratory of the Royal College of Science, London, where the author has been working for the past year as a Board of Agriculture Research Scholar. Through the kindness of Mr. P. Awati, who has been investigating the mouth-parts of *Lygus pabulinus*, Linn., I have been able to examine his sections, and the comparative observations have been most helpful. Mr. Awati is shortly publishing his paper on *Lygus*. The reader is referred to a previous paper by the author on the general anatomy of *Schizoneura lanigera*, which gives a more general description of the alimentary canal and associated structures, and should be read in conjunction with this paper.

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I should like to take this opportunity of expressing my sincere thanks to Professor Maxwell Lefroy for the many suggestions and advice he has kindly given me during the progress of the work, and also to Mr. Clifford Dobell for much valuable assistance in connection with methods of technique and references to literature.

II. Technique and Methods.

Specimens were fixed in Carnoy's fluid and kept in 90 per cent. alcohol. Bouin's picro-formal mixture was also used.

The mode of preparation of material for the paraffin bath was as follows. After passing through the alcohols to absolute alcohol, the material was placed in chloroform for several hours, then in a mixture of equal parts of chloroform and wax and finally in the paraffin bath. Paraffin-wax melting at 58° C. was used and the best results were obtained when the material was left in the bath for about two hours. Only the head was imbedded, but for entire specimens a longer time in the bath is advisable. Sections were cut from 4–10 μ thick, in three planes, transverse, vertical, and longitudinal.

Normal saline solution, glycerine, and turpineol have been used as examination media.

For examination of cleared specimens the material was taken through alcohol and cleared in cedar-wood oil, clove-oil, or turpineol, and mounted in alcoholic or xylol balsam.

Sections were stained with hæmatoxylin (Ehrlich) and orange G or eosin.

For examination of the chitinous parts the material was treated with 10 per cent. potash for several hours and then washed in slightly acidulated distilled water and examined in pure glycerine, or mounted permanently in the usual way in Canada balsam.

The drawings were made from Camera lucida sketches, and owing to the minute detail of the parts very high magnifications were necessary, so that most of the work was done with a $\frac{1}{12}$ oil-immersion lens, and in the case of figs. 4–14 and fig. 24 a No. 18 occulo was used.

III. Nomenclature ; Review of Literature.

The terms used throughout this paper are based solely upon the study of the anatomy, and do not necessarily imply a definite homology with other Hemiptera. It is not intended to discuss in any detail the homologies and morphology of the different parts. As far as possible established names have been given, but generally speaking the terms are mainly used for convenience of description.

Most of the published work dealing with the mouth-parts of Hemiptera is confined to the division Heteroptera. The deflexed position of the head in

the Homoptera gives rise to several structural differences between the two divisions.

The description throughout refers to the head in the feeding position, so that the clypeal or dorsal face of the *fore-head* is spoken of as the anterior or dorsal face, and the surface which is adpressed to the venter in repose, as the posterior or ventral face*. The distal end of the fore-head is towards the extremity of the labrum and the proximal end towards the epicranial region of the head.

Several of the earlier anatomists, for instance Westwood and Burmeister, tried to homologise the mouth-parts of sucking insects with those of the mandibulate or biting insects, and in 1853 Gerstfeld published a paper dealing specially with the mouth-parts of sucking insects. Geise (1883) published a paper on the mouth-parts of *Notonecta, Nepa*, and *Corixa*, and described the salivary pump (Wanzenspritze) which Mayer had described in *Pyrrhocoris apterus* in 1874. Wedde (1885) dealt with the mouth-parts of some Rhynchota and made some observations on the method of suction. Two years later Leon (1887) studied *Pentatoma*, and made observations on the homologies of the parts. The next important paper is that of Heymons (1899), who made many interesting additions to our knowledge of the morphology of the Hemipterous trophi. The most valuable contribution within the last few years is that of Bugnion and Popoff (1911). These authors have dealt specially with *Graphosoma lineatum*, but have also studied several other species of Heteroptera. In an introductory chapter they give many of the different views held by previous workers, as to the homology of the different parts of the trophi.

So far as the Homoptera are concerned very little work has been done. Smith (1892) attempted to homologise the mouth-parts of *Cicada* with those of Diptera, but his work was much criticised by Marlatt (1895). In 1898 Smith published a further paper upholding his views that the proboscis and stylets are maxillary structures, and that no trace of mandibular structures occur in any present form of Hemiptera.

Meek (1913) published an important work on the mouth-parts of *Cicada septendecim*, in which he shows the close relationship existing between the structure of the head and trophi in this Homopterous insect and the many Heteropterous insects that have been studied. He also gave an account of the method of suction. During the past two or three years Muir and Kershaw have made some interesting additions to our knowledge of the morphology of the mouth-parts in Heteroptera and Homoptera. Their conclusions are based chiefly on the study of the development of the embryo of *Pristhesancus papuensis* and of *Siphanta*. They have also made a general comparative study of different families, and have endeavoured to show

* *Vide* footnote on p. 311.

the close relationship that exists between the trophi of Heteroptera and Homoptera.

To supplement this brief review of the literature I shall indicate as far as possible, the relationships which the mouth-parts herein described bear to those studied in other Hemiptera.

The salivary pump is the "Wanzenspritze" noted by Landois (1868) in *Cimex lectularius*. A few years later it was described by Mayer (1874) in *Pyrrhocoris apterus*, and since then, from time to time, by many authors in different species of Hemiptera, including Aphids and Coccids. Muir and Kershaw (1911 *b*) consider that the salivary pump arises as a modified development of the salivary duct.

The morphology of the sclerites forming the head is a much debated question. Owing to the deflexed position of the head in Homoptera the distal part forms a freely articulating chitinous capsule which supports the trophi. This, which is the Vorderkopf of many German authors, I propose to call the *fore-head*. Meek (1903) has described the *fore-head* in *Cicada* as made up of the frons, clypeus, labrum, epipharynx, and the mandibular and maxillary sclerites. The tapering upper lip, which I call the labrum, appears to be the part referred to by Meek as the prolongation of the epipharynx; the labrum he considers as being considerably reduced.

This view is also held by Muir and Kershaw (1911). It will be seen later that I retain the name epipharynx for the specially thick chitinous roof of the pharyngeal duct, which also forms the floor of the part I call the clypeo-labrum.

The structure I refer to as the clypeus corresponds in position to the frons of Meek in *Cicada*. A slight transverse depression divides it off from the clypeo-labrum, but internally it is defined by the presence of the pharyngeal struts, which are really thickened parts of the clypeal folds. The clypeus supports the divaricator muscles of the pharynx.

There is some doubt as to the parts which make up the labium. Geise (1883) considers it as the lower lip. Léon (1887) described rudimentary labial palps in *Hydrocores*; but Heymons (1899) found, by studying the development in the embryo, that the proboscis is formed by the fusion of a simple pair of appendages (2nd maxillæ), which bear no trace of palps. He considers these latter structures arise as secondary developments. Muir and Kershaw (1911) have shown that the proboscis is formed by the fusion of the simple 2nd maxillæ, and afterwards becomes secondarily divided into segments; they found no clue to the missing palps.

The morphology of the stylets is a much debated point. Originally it was thought that they represented the maxillæ and mandibles. Smith (1892) drew attention to the fact that certain sclerites, which formed part of the chitinous capsule of the *fore-head*, were really associated during development with the stylets, so that the stylets do not really represent the complete mandibles and maxillæ.

Heymons (1896–8) showed from embryology that the internal or posterior stylets represent only part of the first maxillæ. During development the basal portion of each maxilla forms a chitinous plate, which fuses with the wall of the head. The work of Muir and Kershaw (1911) has confirmed this both in Homoptera and Heteroptera ; hence this pair of stylets I have called the maxillary stylets, and their sclerites the maxillary sclerites.

Bugnion and Popoff (1911) consider the anterior or dorsal pair of stylets also represent only part of the mandibles in Heteroptera, the basal portion of the mandible forming a sclerite which fuses with the wall of the head.

Meek also considers that mandibular sclerites (lorœ) are present in *Cicada*.

The later work of Muir and Kershaw (1911–12) on the embryology of *Pristhesancus papuensis* and *Siphanta* shows that the mandibular sclerites (so-called) have no relation to these stylets, and are not derived from them, and thus I call these stylets the mandibles. The structures I refer to as the clypeal sclerites agree in position with the lorœ or mandibular sclerites of Meek.

IV. Anatomy of the Head and Mouth-parts.

A. *External Structure.*

The *head* in repose is strongly deflexed beneath the anterior end of the body. On examination of its anterior face, it is seen to be divided into two distinct portions by a transverse suture, situated near the vertex. The proximal portion, which bears the eyes and antennæ, comprises the *epicranial region*. The distal portion is conical in shape and tapers distally, forming a stout, chitinous capsule which supports the trophi. For purposes of description I shall refer to the structure as the *fore-head* *. It freely articulates with the epicranial region by means of thin, flexible chitin (Pl. 24. fig. 1, *a.f.*), which allows freedom of movement, enabling it to be raised or deflexed at will.

The epicranial region is broad and convex and is continuous at its proximal end with the prothorax.

The fore-head is strongly convex on its anterior and antero-lateral faces, and is composed of several chitinous plates or sclerites.

The post-lateral walls, *vide* fig. 18 (Pl. 25), are flat and composed of thinner chitin.

In the distal half of the fore-head the integument folds into the interior, between the sclerites, forming well-defined chitinous folds, as indicated in text-fig. 1.

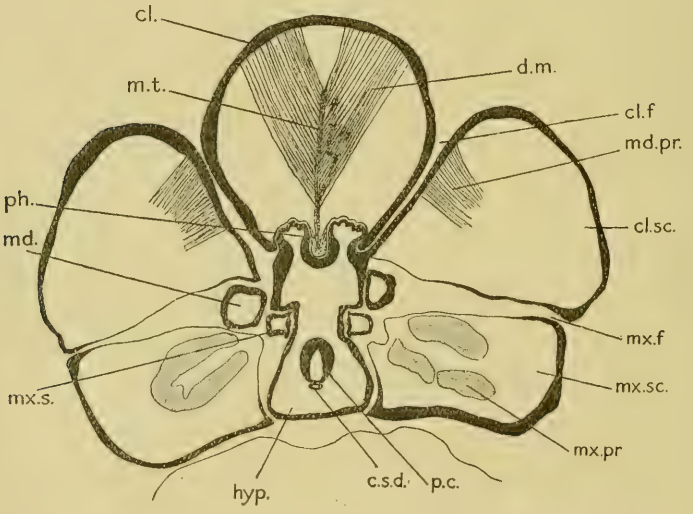
Looked at from its anterior face, the fore-head is seen to consist of dome-shaped areas, *vide* fig. 1.

* In a previous paper I called this structure the frons. This term is misleading. It is the Vorderkopf of many German authors and for want of a better word I use the literal translation *fore-head.*

A large median plate, which I call the *clypeus, cl.*, extends from the proximal margin of the fore-head and forms the greater part of the anterior face. Distally it narrows somewhat, and is divided by a shallow, transverse depression from a smaller triangular sclerite, *cl.l.* This I call the *clypeo-labrum.* It seems to be really a continuation of the clypeus. A tapering plate of chitin, the *labrum*, *lbr.*, extends in the median line from the distal end of the clypeo-labrum.

The floor of the clypeo-labrum, Pl. 24. fig. 1, *e.p.*, is composed of thick chitin, which forms the roof of the pharyngeal duct, *ph.d.* This is the *epipharynx.* It possesses a deep, longitudinal groove on its internal face.

Text-fig. 1.



Transverse section through the fore-head in region of pharynx protuberances, showing relation of sclerites forming the fore-head. ×300.

(For explanation of lettering see p. 329.)

as is shown in transverse sections, figs. 7–9, which affords a support for the maxillary stylets.

Distally, it is continuous with the internal face of the labrum, but the chitin becomes much thinner.

The labrum possesses a few, small, transverse ridges on its outer face and a longitudinal groove on the internal face. It is connected with the clypeo-labrum by a thin chitinous fold, which permits free movement.

Two folds of chitin, the *clypeal folds*, text-fig. 1, *cl.f.*, extend into the fore-head on each side of the clypeus, and become continuous with the dorsal wall of the pharynx.

At the anterior end of the pharynx the walls of the fold are composed of very stout chitin and form two strong chitinous struts, the *pharyngeal struts* (*ph.st.*, figs. 13 & 14), which extend to the antero-lateral walls of that structure, affording a firm support for it. The clypeal folds separate the clypeus from two lateral sclerites, the *clypeal sclerites*, *cl.sc.* (mandibular sclerites or loræ of some authors).

Two *maxillary sclerites*, *mx.sc.*, are situated below the clypeal sclerites, and help to form the latero-ventral walls of the fore-head. They extend ventrally towards the mid-ventral line. In the post-ventral region they merge into the floor of the fore-head which is composed of thin chitin, fig. 18, *f.h.*

Distally, the maxillary sclerites lie close together in the mid-ventral line and extend beneath the clypeo-labrum and labrum. They are separated for some distance, however, by a median plate of chitin which merges proximally into the ventral wall of the fore-head. This is the *hypopharynx*, *hyp.* It is continued forward beneath the *pharyngeal duct*, *ph.d.*, as a small *hypopharynx lip*, *hyp.l.*, fig. 1. The maxillary sclerites, closely apposed in the median line, extend beneath the hypopharynx lip, concealing it from the ventral aspect, and form two tapering processes, the *maxillary processes* as seen in sections, figs. 4–7, and shown in fig. 2, *mxp.*

The maxillary sclerites turn inwards on each side of the hypopharynx and form two deep folds, the *buccal folds*, *b.f.* These folds remain open throughout and form two large cavities or chambers, the *buccal cavity*, *b.c.*, which accommodate the stylets. Towards the distal end, the internal faces of the maxillary sclerites and maxillary processes are composed of stout chitin, and ar grooved, thus affording support for the stylets, figs. 6–8.

The hypopharynx lip extends beneath the pharyngeal duct, forming the ventral wall of that structure. Proximally the lip dips down and becomes continuous with the broader portion of the hypopharynx, *hyp.* A large bay is thus formed in which the *salivary pump*, text-fig. 2, *s.p.*, is situated, being attached to the wall of the hypopharynx by means of a stout chitinous supporting base, figs. 2, 12, 13, and 23, *p.s.*

The *salivary pump* can be seen through the integument in cleared specimens as a dark "Ψ"-shaped chitinous structure.

The floor of the fore-head, into which the hypopharynx merges at its proximal end, becomes continuous with the dorsal wall of the *proboscis* or *labium*, fig. 1, *lbm.*, and text-fig. 2 (p. 325). This latter structure turns beneath the hypopharynx, and at its proximal end its walls consist of thin, flexible chitin.

The post-lateral walls of the fore-head are composed of thinner chitin, fig. 18, *l.w.* When viewed from the anterior or dorsal face, in cleared specimens, there appears to be a ridge of chitin running along the lateral edges of the clypeus. This however, is due to the thick chitin of the clypeus joining on to the thinner lateral walls of the fore-head.

The clypeal sclerites and maxillary sclerites are separated by the *maxillary folds*, *mx.f.* These represent the mandibular folds of Muir and Kershaw. As in the case of the clypeal folds, the in-turned edges of the maxillary and clypeal sclerites are held firmly together by connective tissue. In sections the connective tissue tears away and the sclerites become separated. The maxillary and clypeal folds extend towards the proximal end of the fore-head, where the sclerites merge together to form its lateral walls.

The internal, lateral walls of the hypopharynx (figs. 11–14) are composed of stout chitin and become continuous with the wall of the pharynx, forming part of the stout chitinous supports which surround its anterior end. The pharynx is held firmly in position by these supports, *vide* fig. 14.

B. *The Endoskeleton of the Head.*

The *endoskeleton of the head* consists of strong, hollow, chitinous bars, formed by invaginations of the integument of the head. These bars, which form the arms of the tentorium, give support to the fore-head, and also afford attachment for several muscles. Figs. 2 and 3 show the chitinous endoskeleton as seen in potash preparations of the head.

The arms of the tentorium expand at their extremities and form a broad, hollow, *transverse plate*, *t.p.*, which is situated in the posterior region of the head, beneath the supra-œsophageal ganglion, and forms the central support of the tentorium. The antero-dorsal arms, the antero-ventral arms, and the ventral rods *, are attached or continuous with the transverse plate. The chitin of this latter structure is thinner towards the middle, but becomes much stronger towards its ends, from whence the tentorial arms pass.

The *antero-dorsal arms*, *a.d.*, are formed by two invaginations at the posterior end of the clypeal region of the head. They extend in a posterior direction to the transverse plate, fig. 3, *a.d.*

The *antero-ventral arms*, *a.v.*, pass forward ventrally, diverging from one another, towards the infra-posterior angles of the fore-head. Each then bends upwards, along the lateral wall, and ends at the proximal end of the maxillary fold. From this region a stout triangular bar of chitin passes into the fore-head from each side, which form two levers, *md.l.*, for the dorsal or anterior pair of stylets (mandibles). The position of these levers corresponds to the position of the ends of the maxillary folds, and each lever appears to be a thickening of the fold in this region, fig. 16, *md.l.*, being part of the clypeal sclerite.

The *ventral chitinous rods*, *v.r.*, fig. 2, and also in figs. 18–21, originate at the posterior ends of the buccal folds, and passing beneath the large pump-

* These terms are used for convenience in description, and are not necessarily homologous with the arms of the tentorium as described by Comstock (1902) in insects generally.

muscle, *p.m.*, they become continuous at their proximal ends, by means of thinner chitin, with the middle of the transverse plate *.

A narrow curved rod of chitin, *mx.l.*, articulates at the proximal end of each maxillary sclerite, where that structure fuses with the general wall of the fore-head, and near the base of the mandibular lever on each side. They both pass inwards to become attached to the proximal ends of the internal or ventral stylets (maxillary stylets), and thus form the *maxillary levers, mx.l.*, figs. 2, 3, and 17.

C. *The Labium.*

The *proboscis* or *labium* (*lbm.*) is formed by an evagination of the integument at the infra-posterior end of the head. In repose it lies closely adpressed against the ventral surface of the body, between the coxæ, and extends for some distance beyond the third pair. It consists of three segments, text-fig. 2, a long proximal segment and two shorter distal segments. Its dorsal or anterior face is folded to form a median, longitudinal groove, which extends along the greater part of its length. At the extremity of the distal article the walls of the fold close completely over, thus forming a short tube, but throughout the rest of its length the groove is open. The proximal end of the proboscis is composed of thin, flexible chitin, as is shown in fig. 1. It is this part which is capable of being drawn into the body during feeding, as will be explained later. This proximal end is not grooved. When specimens are examined, the stylets are usually found lying in the proboscis groove, being held in it by the short, closed tube at its extremity. They are often found extending through the end of this tube, beyond the tip of the proboscis. The distal article of the proboscis bears on its extremity a ring of tactile hairs. During feeding, the proboscis is raised from the surface of the body, and its anterior face is closely pressed against the hypopharynx and maxillary processes.

D. *The Pharynx.*

The *pharynx* (*ph.*) extends through the head in the median line, and passing over the transverse plate of the tentorium, leads into the œsophagus, fig. 1.

When a cleared potash preparation of the head is examined from the dorsal aspect, two conspicuous prominences are seen at the anterior end of the pharynx. These are the *pharynx protuberances*, *p.p.*, figs. 12, 13. They are the "Näroiden" described by Dreyfus (1894) in *Phylloxera*. It is in

* Mordwilko (1895) has described these rods in *Lachnus*, as the "Chitinfortsatzestabchen." He considers they are free at their proximal ends. By means of serial sections I have traced these rods in *Schizoneura* to the transverse plate to which they are attached by thin chitin.

this region that the stout pharyngeal struts and the thick, internal walls of the hypopharynx meet, thus forming a firm support for the pharynx.

The pharynx proper (*i. e.*, the part which exerts the sucking force) begins here, and as is seen in the transverse sections, figs. 12–22, the dorsal wall is composed of thin flexible chitin, which is acted upon by large *divaricator muscles*, *d.m.* Anterior to the pharynx protuberances the continuation of the pharynx dips down, and its walls are entirely composed of very stout, rigid chitin, figs. 7–11. The thick chitinous upper wall is formed by the *epipharynx*, *e.p.*, and the lower wall by the *hypopharynx*. This portion does not exert any sucking action, and is simply a duct, *the pharyngeal duct*, *ph.d.*, which conveys the plant-juices into the pharynx proper. This duct, as will be shown later, leads directly into the suction-canal formed by the approximation of the maxillary stylets. The pharynx proper extends from the position of the pharynx protuberances to the transverse chitinous plate of the endoskeleton. It is concave in section, the thin dorsal wall fitting against the stout ventral wall, and possesses a fairly wide lumen.

The *pharynx protuberances* are two hollow, dome-shaped prominences, formed by the meeting of stout chitinous arms in this region, as shown in figs. 12 and 13. They afford a strong support for the anterior end of the pharynx. The dorsal wall of the pharynx, which is thin and flexible, fits snugly between the protuberances into the deep bay formed by the thick ventral wall. In this region the dorsal wall is acted upon by strong divaricator muscles, *d.m.*, which are attached to a median, vertical tendon, *m.t.* It will thus be seen that when these muscles are relaxed, the upper wall of the pharynx fits closely against the ventral wall between the protuberances and practically occludes the opening into the pharynx, thus acting as a kind of entrance-valve. It seems to me, therefore, that the function of the protuberances is simply to strengthen the anterior end of the pharynx, and to render this valvular action more complete.

The *pharyngeal duct*, which really forms part of the pharynx, can be discussed separately, because its function differs from that of the pharynx proper, in that it exerts no sucking-force, but is simply a conducting-canal through which the plant-juices are conveyed from the suction-canal.

The *pharyngeal duct*, figs. 10 and 11, *ph.d.*, dips down and leads to the extremity of the hypopharynx lip *. Its roof is formed by a specially thick plate of chitin, which also forms the floor of the clypeo-labrum, *cl.l.* This structure is the *epipharynx*, *ep.*, figs. 3 and 7–11.

* The mouth, or oral opening, which is really the entrance from the buccal cavity into the pharynx, may be considered as being here. Owing to the special mode of feeding in Hemiptera however, the food-juices, as will be shown later, really enter at the extremity of the compound maxillary stylet, and pass upwards through a special canal into the pharyngeal duct, so that the actual mouth is situated at the extremity of this stylet.

E. *The Epipharynx.*

When examined in transverse sections, fig. 9, the epipharynx is seen to be deeply grooved on its internal face, affording, towards its distal end, a kind of bay in which the maxillary stylets are snugly fitted.

In cleared preparations of the head, fig. 3, the epipharynx is seen to possess a median row of eight well-formed pores, and these are also seen in median longitudinal sections, figs. 1 and 25. Dreyfus (1894) has figured and described a similar structure in *Phylloxera*, and calls it the hypopharynx. He has also figured the eight pores, but considers these "pale spots" as small chitinous pegs. It may not be out of place here to emphasize the need of verifying observations made on cleared specimens by means of sections. The danger of misinterpreting deeply-seated chitinous structures from cleared transparent specimens is very great, and serial sections are indispensable if a true interpretation of internal chitinous structures is to be gained.

In longitudinal sections the epipharynx appears as a perforated plate, and is probably the perforated languette described by Bugnion and Popoff (1911), and also by Wedde (1885) in other Hemiptera.

Lying above the anterior end of the pharynx and extending over the pores in the epipharynx is an irregular group of cells, possessing large, deeply-staining nuclei, but cell-walls are not defined, fig. 25, *g.o.*

This structure is found in all sections. Behind the epipharynx it seems to divide into two lobes which extend one on each side of the divaricator muscles. In longitudinal sections taken a little out of the median line, I have found a nerve passing from the two anterior lobes of the supra-œsophageal ganglion to each lobe of this structure.

From its position over the perforated epipharynx this structure would seem to be a *gustatory organ.* An organ in this position has been described by Bugnion and Popoff (1911) in Heteroptera, and also by Wedde (1885), but as far as I am able to see with the sections I have made, the histological structure does not agree with the figure given by the former authors. It certainly does not appear to be a glandular structure. I hope in the near future to make special preparations and sections to show the structure of this organ, which will demand the application of special methods. From indirect evidence it would appear that it is an organ of taste, which enables the aphid to test the nature of the sap drawn into the pharyngeal duct before it enters into the pharynx proper.

That aphids are able to readily appreciate differences in the plant-juices derived from different plants is quite certain from observations I have made this year during the progress of some experiments with *Aphis rumicis.* There is no other organ present which could exert such a function. The tactile hairs at the extremity of the proboscis only serve to enable the aphis to find a suitable tender part of the plant in which to insert its stylets.

I have given a longitudinal section, fig. 25, through the epipharynx, showing the position and structure, so far as I am able at present, of this gustatory organ. The section is not quite median, so that the surrounding chitinous structures are not shown very clearly.

F. *Musculature of the Pharynx.*

The anterior or dorsal wall of the pharynx is acted upon by powerful bands of divaricator muscles, which pull out this flexible dorsal wall, thus greatly increasing the lumen of that structure. In the distal half of the pharynx an upright membrane or tendon, *m.t.*, is attached along the middle of the pharynx-wall, and to this tendon are attached the divaricator muscles, *d.m.*, as is shown in figs. 12–16. The muscles pass from each side of this median tendon in parallel bands, and become attached to the wall of the clypeus, on each side of the median line. The internal face of the clypeus possesses several, small, projecting ridges of chitin, which afford a firm attachment for the muscles. These muscles extend to the clypeus in a slightly posterior direction, so that in transverse sections they are often cut across, as shown in fig. 17.

The muscles attached to the proximal end of the dorsal wall of the pharynx are smaller. They converge towards the post-dorsal wall of the clypeus, becoming inserted on its internal face, near together, on each side of the median line.

In fig. 1, which is a slightly schematized median, longitudinal section through the head, the muscles are cut through obliquely and pass out of the line of section before reaching the clypeus.

Between the pharynx protuberances, the pharynx is narrow in transverse section, figs. 12 and 13, and "U"-shaped. When the divaricator muscles are relaxed, the flexible dorsal wall becomes closely adpressed against the ventral wall, completely closing the lumen.

G. *The Salivary Pump.*

The *salivary pump* is a bell-shaped chitinous structure situated below the anterior end of the pharynx, being attached to the hypopharynx, *vide* fig. 2.

In longitudinal section, *vide* fig. 1, it is seen to consist of a stout chitinous distal portion, forming the handle of the bell. This is the *pump-stem*, *p.s.* It widens out at its proximal end to form a cup-shaped portion—the body of the bell—which is the *pump-cylinder*, *p.c.* These parts are perhaps better shown in vertical section, fig. 23.

The *pump-cylinder* is a thick-walled, cup-like structure, composed of thick chitin which encloses the *pump-chamber*, *p.ch.*

The proximal wall of the cylinder consists of membranous chitin, which is continuous with the thick rim of the cup. This wall is usually seen withdrawn into the cylinder, so that only a small part of the chamber remains showing. Attached to this proximal wall is a small club-like tendon to

which the large pump-muscle, *p.m.*, is attached. This muscle when it contracts pulls out the proximal wall, thus enlarging the pump-chamber, but in sections the muscle is always seen in the relaxed condition and the pump-chamber is considerably reduced in size, and difficult to see.

The *pump-stem* is attached at its distal end to the wall of the hypopharynx. It is compressed laterally, figs. 12–13. Two strong arms of chitin extend from it laterally and fuse with the lateral walls of the hypopharynx, thus affording a firmer support for the pump.

A minute canal (figs. 12 and 13, *s.ed.*), the *efferent salivary canal*, extends through the dorsal part of the pump-stem, along which the saliva is conducted into the *ejector canal*, *e.c.*, formed by the junction of the maxillary stylets.

The *efferent salivary canal* is continued beyond the pump-stem along the ventral wall of the small hypopharynx lip, being enclosed by this wall, and extends to its pointed extremity (figs. 1 and 10–13, *s.ed.*), where it is continued into a small chitinous process. A similar process extends from the dorsal wall of the lip. There is thus formed a "V"-shaped cleft at the extremity of this structure, as is shown in fig. 25. As will be shown later, the dorsal process forms the continuation of the pharyngeal canal, which leads into the suction canal formed by the maxillary stylets. Similarly the ventral process enclosing the efferent salivary canal leads into the ventral or ejector canal formed by the maxillary stylets.

The *salivary glands* * are situated above the œsophagus, and lie obliquely partly in the prothorax and partly in the posterior region of the head, one pair on each side of the median line. The *salivary duct* from each pair passes beneath the thoracic ganglia, and both meet in the median line at the infra-posterior region of the fore-head, where they form a bulbous expansion, *c.s.d.*

From this structure a single *median salivary duct* passes forward into the fore-head. It becomes greatly reduced in size, and extending in the median line beneath the salivary pump, turns upwards, forming an "S"-shaped flexure, and enters the pump-chamber at the post-ventral end of the pump-cylinder, as is shown in fig. 1.

At the place of entry of the salivary duct into the pump-chamber, the walls are so arranged that they exert a valve-like action, the opening being controlled by two small bands of muscles, the *ventral pump-muscles*, *v.m.*, figs. 1 & 2, and figs. 15–18. These muscles are attached, close together, to the wall at the place of entry, and extend backwards below the large pump-muscle, becoming attached to the ventral rods of chitin. The lumen of the salivary duct is extremely small.

The exit opening from the pump-chamber is situated at the antero-dorsal end of the cylinder (fig. 1), and leads into the *efferent salivary canal*, described above as passing through the pump-stem.

* For further description of the salivary glands see Quart. Journ. Micr. Sci. vol. lviii. (1913) p. 680.

H. *Musculature of the Salivary Pump.*

The structure of the salivary pump is such that it acts as a force-pump, the working of which is controlled by the large spindle-shaped *pump-muscle* shown in fig. 1 and fig. 2, *p.m.*

The pump-muscle is attached to the flexible, proximal wall of the cylinder and extends beneath the pharynx, towards the transverse plate of the tentorium, being partly attached to the latter structure and partly to the stout ventral wall of the pharynx. It is divided for some distance along its length, as is seen in transverse sections. The musculature will be considered in more detail later.

I. *The Stylets.*

The *stylets* are situated below the pharynx, and consist of two anterior or dorsal stylets, the *mandibles* (*m.d.*, fig. 3), and two posterior or ventral stylets, the *maxillary stylets* (*mx.s.*, fig. 2).

They are withdrawn for some distance into the fore-head, being swollen in a club-shaped manner at their proximal ends. Distally they become considerably reduced in size, and form long, needle-like structures which, passing through the buccal cavity, extend along the longitudinal proboscis groove. They are finely pointed at their distal extremities, *vide* fig. 24.

The stylets are hollow chitinous structures, which are continuous with the integument of the posterior end of the buccal cavity, being drawn inwards somewhat after the manner of an inverted finger of a glove, *vide* fig. 23. The cavity of the stylet-shaft is especially large in the swollen, proximal part. From the proximal end of each emerges the retort-shaped organ indicated in the series of transverse sections, *md.o.*, *mx.o.*

The relation of the stylets to other structures in the fore-head will be best understood from the serial sections, figs. 4–18.

The maxillary stylets.

The *maxillary stylets* lie ventral to the mandibles, one on each side of the median line, and are situated further back. As they emerge into the buccal cavity they approximate towards each other, becoming considerably reduced in size. As is seen in fig. 23, the integument of the buccal cavity, which in this region is thin and membranous, is continued proximally along the shaft of the stylets, forming a sheath in which those structures are freely moveable.

As the maxillary stylets enter the buccal cavity they lie one on each side, along the internal lateral walls of the hypopharynx (fig. 15), fitting into a longitudinally running bay or groove.

Running along the internal face of both stylets is a median longitudinal ridge. This causes two longitudinal grooves to be formed, a dorsal and a ventral groove.

As the stylets extend towards the extremity of the hypopharynx lip, they gradually approach towards the median line, the longitudinal ridge and the two grooves on the internal face becoming more pronounced. At the extremity of the hypopharynx lip they meet in the median line, and the two internal faces become apposed. There is thus formed between the stylets two longitudinal canals (figs. 8 and 9) which are more or less separated by the close apposition of the two longitudinal ridges formed on the internal faces.

I have mentioned before that the tip of the hypopharynx lip possesses a "V"-shaped cleft, owing to the slight prolongation of the two processes which support the openings into the pharyngeal duct and efferent salivary canal. As will be seen in fig. 9, the longitudinal ridges on the internal faces of the maxillary stylets fit into this "V"-shaped cleft, and the dorsal and ventral canals formed by the junction of these stylets enclose the two processes, thus establishing direct communication with the two canals and the pharyngeal duct and efferent salivary canal respectively.

The maxillary stylets do not actually fuse when they meet, but towards their extremity they appear to do so, although the line of fusion is clearly marked.

The compound stylet thus formed possesses two well-marked canals, which run throughout its length :—The dorsal *suction-canal*, *s.c.*, which conveys the plant-juices to the pharyngeal duct, and thus into the pharynx and a ventral canal. The ventral canal is slightly smaller : it is the *salivary ejector canal*, *e.c.*, and conveys the saliva from the efferent salivary duct into the tissues of the plant.

Beyond the extremity of the hypopharynx lip, the compound maxillary stylet is supported above in a deep groove on the ventral face of the epipharynx, and below, by grooves on the internal walls of the maxillary sclerites. As is seen in figs. 7, 8, and 9, these surfaces are so arranged that the stylet fits snugly into the grooves, being held firmly in position, at the same time having perfect freedom of movement for protraction or retraction.

Beyond the region of the epipharynx the maxillary processes and the labrum—which is grooved on its ventral face—afford a firm support for the stylets.

Towards the extremity of the labrum the compound stylet enters into the longitudinal proboscis-groove and extends along it to the extremity of the proboscis.

The maxillary levers.

The *maxillary levers* are two curved rods of chitin which articulate one at the proximal end of each maxillary sclerite ; each passes into the fore-head, beneath the maxillary stylets (figs. 2 & 3, *mx.l.*, and fig. 17), to the swollen proximal ends of which they become attached, thus affording moveable supporting levers for those structures. The levers project a little way beyond the internal face of the stylets, as shown in figs. 2 and 18, and thus afford attachment for some of the retractor muscle-bands, *mx'.re.*

The mandibles.

The anterior stylets are the *mandibles*. They lie dorsal to the maxillary stylets, being disposed slightly further from the median line (fig. 3, *md.*). Although slightly longer, they resemble the latter in general appearance, but remain separate throughout. As they enter the buccal cavity they approximate towards the median line, and extend above the maxillary stylets along the internal walls of the hypopharynx (*vide* figs. 4–14).

Towards the extremity of this structure the internal faces of the mandibles are somewhat concave, and fit closely against its lateral walls. Beyond the junction of the maxillary stylets the mandibles lie by the side of the compound stylet, the internal concave faces of the former closely fitting against the convex outer faces of the latter. They then extend by the side of this stylet along the proboscis-groove.

The mandibular levers.

The mandibles are supported by two stout arms of chitin (*md.l.*, fig. 3), which extend, one on each side of the fore-head, from the proximal end of the maxillary fold (fig. 16). They are much stronger than the maxillary levers. Each passes to the base of the mandibles, to which they become attached.

J. *Musculature of the Stylets.*

The mandibles and maxillary stylets can be protracted or retracted by a system of protractor and retractor muscles.

The *retractor muscles of the mandibles* are inserted on the internal face, at the proximal end of those structures (fig. 3, *md.re.*, and figs. 16–21), and extending backwards into the head, divide into two groups, one group becoming inserted along the antero-dorsal arms of the tentorium, the other on the transverse plate of chitin, at the base of these arms.

The *protractor muscles*, *md.pr.*, are inserted along the base of the mandibular lever, and pass forwards to become inserted along the pharyngeal struts.

The *retractor muscles of the maxillary stylets* (fig. 2, and figs. 18–21, *mx.re.*) consist of two groups of muscles. One group is inserted on the internal face

of the proximal extremity of each stylet *, and passing backwards through the head they become attached to the antero-ventral arms of the tentorium, at the base of those structures where they join the transverse plate.

The other group of muscles is smaller, and is attached to the projecting portion of the maxillary lever. The muscles from each lever extend laterally through the head to become inserted on the antero-ventral arms of the tentorium, at the place where that structure bends into the fore-head, *vide* figs. 2 and 18, *mx'.re.*

The large *protractor muscles of the maxillary stylets* are inserted along the external face of the prolonged base of each stylet, and extend in an anterior direction to become inserted on the walls of the maxillary sclerites (fig. 23, *mx.pr.*).

K. *Musculature of the Head.*

I have shown that the fore-head freely articulates with the proximal portion of the head by means of a membranous chitinous fold. This allows the fore-head to be raised from the deflexed position it occupies in repose, to a position more or less at an angle to the body, which it occupies when the aphis is feeding. These movements are brought about by two sets of muscles, the *elevator muscles* of the fore-head and the *depressor muscles.*

Extending from the transverse plate of chitin are two bands of muscles which pass through the proximal portion of the head, in a postero-lateral direction, and become inserted on the post-lateral border of the head, at its junction with the prothorax. These muscles are not shown in fig. 1, as they are attached at the ends of the transverse plate, and are not seen in median section. I have indicated them in the schematic text-figure 2, *m.d.p.* When these muscles contract they pull down the transverse plate of the tentorium, and as this structure, by means of the tentorial arms, is firmly attached to the fore-head, this latter structure is elevated from its deflexed position. I call these muscles therefore, the *elevator muscles of the fore-head.*

The *depressor muscles of the fore-head* consist of two strong muscles which are attached, in the median line, to the floor of that structure (figs. 18 & 19, *m.d.f.*). They diverge laterally, in a slightly posterior direction, and become inserted on the antero-ventral arms of the tentorium. When the aphis has

* Muir and Kershaw (1912) consider that the part of the stylets projecting into the head and supporting the retractor and protractor muscles are chitinized tendons originating "by the invagination of the ectoderm at the base of the setæ, which becomes solid, or partly solid, by deposits of chitin." As may be seen in fig. 23, the maxillary stylets are apparently continued for some little distance into the head, thus affording attachment for the muscles. This part is chitinous, and in the case of the mandibles the chitin possesses small chitinous papillæ, which afford firm attachment for the retractor muscles. The base of the stylets seems to be continued into the head for a short distance beyond the continuation of the integument of the buccal cavity, thus affording an attachment for the muscles.

finished feeding, and these muscles contract, the fore-head is pulled back into the normal deflexed position.

There are two other bands of muscles attached to the ends of the transverse plate of chitin (text-fig. 2, *m.e.p.*). They extend through the head, almost parallel, in a plane continuous with that of the large pump-muscle, and are inserted on the wall of the head. These are the *elevator muscles of the transverse plate*. From their position the function undoubtedly is to counteract the pull on this structure, of the large pump-muscle and the retractor muscles of the stylets.

I have shown that the salivary pump is held firmly in position by chitinous supports. When the large pump-muscle contracts, thus operating on the proximal wall of the pump-cylinder, there must be also a considerable pull on the transverse plate, and if this structure were allowed to be pulled in the direction of the pump, the muscle would be deprived of a considerable amount of its force exerted on the pump. This is overcome by the action of the elevator muscles of the transverse plate. When these muscles contract they exert a pull along the same plane as the pump-muscle, but in the opposite direction.

L. *How Suction is accomplished.*

I have indicated when describing the anatomy of the mouth-parts how the plant-juices are conveyed into the pharynx, and how the saliva is conveyed into the plant-tissues.

I shall now give a concise account of the way it seems to me the mouth-parts work during the operation of feeding.

Owing to the minute structure concerned it has not been possible to work the parts experimentally, or to observe them working in the living insect, so that the following conclusions have been arrived at by means of a careful study of the anatomy, and especially the distribution of the muscles.

The proboscis is raised from the body, and a suitable part of the plant-host is selected in which to insert the stylets. The distal article of the proboscis is freely moveable, and exerts a tactile function by means of the tactile hairs on its extremity.

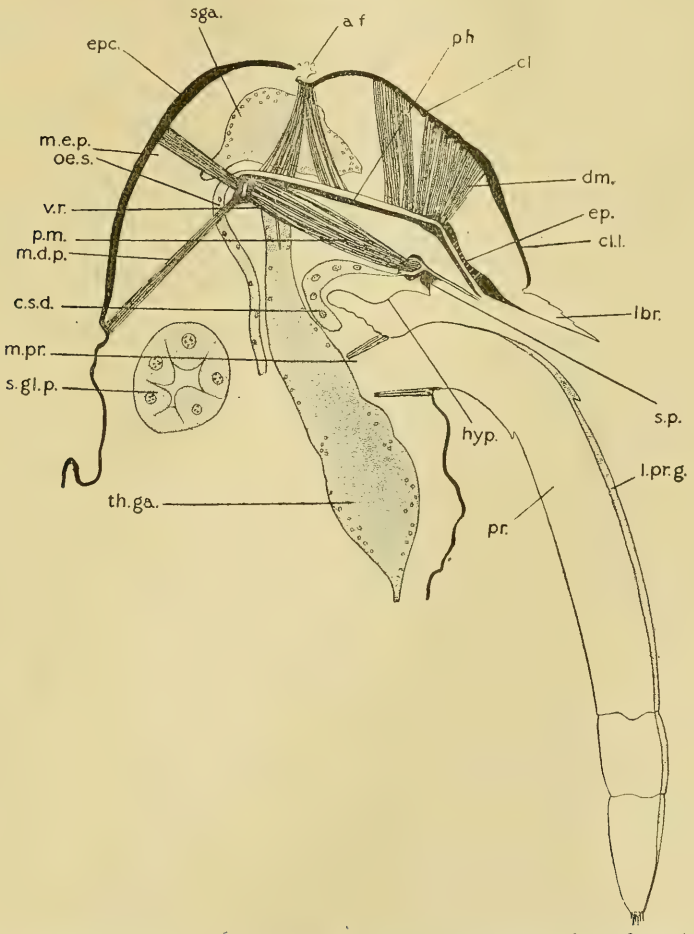
The fore-head is also raised from its deflexed position by the contraction of the two elevator muscles of the fore-head (*m.d.p.*). The stylets lie along the longitudinal groove on the anterior face of the labium, to which the labrum is closely adpressed.

The fore-head and proboscis are now in the position for the working of the stylets.

By means of the large protractor muscles (fig. 23, *mx.pr.*), the compound maxillary stylet is forced into the tissues of the plant. This stylet, as has been described above, is held firmly in position by the deep grooves on the internal face of the epipharynx and labrum and the grooves on the internal walls of the maxillary sclerites. Proximally, before they come together, the

two maxillary stylets work smoothly along the internal walls of the hypopharynx. As they lie along the proboscis-groove, they are held in position at the extremity of the proboscis by the folding over of the walls of the groove, which thus forms a tube through which the stylets pass into the plant.

Text-fig. 2.



Schematic longitudinal section through the head, showing relation of parts. × 160. The stylets have not been shown, in order to avoid confusion. The working of these structures will be readily understood from figs. 2 and 3.

At the same time the large protractor muscles of the mandibles (*md.pr.*) contract, and pull down the mandibular levers, so that the mandibles are also forced into the plant *.

* From examination of some sections of plant tissues with the stylets in position (*Aphis rumicis* on *Chenopodium album*), the stylets were found to pass between the cortical cells in a more or less irregular course to the vascular bundles.

During the insertion of the stylets, the proximal part of the proboscis is withdrawn into the body by the protractor muscles (*m.pr.*). This enables the stylets to be forced deeper into the tissues of the plant; at the same time they are strengthened by being supported outside the plant in the proboscis-groove. I have indicated above, that the proximal end of the proboscis is very thin and membranous, which allows it to be readily retracted.

The mandibles remain free throughout, although they are closely apposed to the compound maxillary stylet, and strengthen this structure during the piercing of the plant-tissues.

When the stylets have been forced into the desired part of the plant-tissues, suction commences.

Owing to the very minute lumen composing the suction-canal, *s.c.*, it is very probable that the plant-juices ascend up this canal, largely by means of capillarity, and there is the further factor of the pressure of the sap itself.

As the divaricator muscles of the pharynx contract, they pull out the flexible, dorsal wall of the pharynx, thus greatly enlarging the lumen of that structure. This causes a sucking action, and as the plant-juices make their way from the suction-canal up the pharyngeal duct, they are drawn from the latter duct into the pharynx proper.

The divaricator muscles acting on the posterior half of the pharynx are not so strong as those acting on the anterior half. I have shown that the stout, ventral wall of the pharynx between the pharynx protuberances is deeply concave, so that when the divaricator muscles of this part are relaxed the dorsal wall becomes adpressed to the ventral wall and practically occludes the entrance from the pharyngeal duct. As the other divaricator muscles are relaxed the dorsal wall tends to regain its original position by virtue of its own elasticity, and as a result, the lumen being considerably reduced in size, the juices are forced backwards into the œsophagus, and thus into the stomach. At the entrance of the œsophagus into the stomach, there is formed a well-defined œsophageal valve, which prevents regurgitation of the food into the pharynx *.

The working of the salivary pump is produced by the large pump-muscle, *p.m.* When this muscle contracts, the proximal wall of the pump-cylinder is pulled out (fig. 23), thus enlarging the lumen of the pump-chamber. By the contraction of the small ventral muscles, fig. 25, *v.m.*, the entrance from the median salivary duct into the pump-chamber is opened and the saliva passes into the pump-chamber.

It will be noticed in fig. 23 that the thick proximal rim of the pump-cylinder, which is slightly inturned, is also pulled out, and the strong walls of that structure are thus forced outwards, which is rendered possible by the elasticity of the thick chitin. It is for this reason that the pump-muscle is

* Davidson, J., Quart. Journ. Micr. Sci. vol. lviii. (1913) p. 680.

so powerful, as the force required to squeeze out the walls of the cylinder must be very considerable. The resulting pull on the transverse plate of the tentorium must be very great, and to counteract this there are the two elevator muscles of that structure, *m.e.p.* These muscles exert a pull in the same plane as the pump-muscle, but in the opposite direction.

If the only function of the pump-muscle were to pull out the flexible proximal wall such great force would not be needed. Further, it is very improbable that the return of this wall would give sufficient force to propel the saliva from the pump-chamber, along the minute efferent salivary canal, and then down the ejector canal formed between the maxillary stylets.

When the saliva has collected in the pump-chamber the small ventral muscles (*v.m.*) are relaxed and the opening from the median salivary duct (afferent canal) is closed. The large pump-muscle is then relaxed and the walls of the pump-chamber return to their normal position. The force of the contracting walls of the cylinder is such that the saliva is forced into the efferent canal, down into the ejector canal. The flexible proximal wall of the cylinder gradually returns to its normal position and the cavity of the chamber is considerably reduced in size, the contents being forced down the salivary ejector canal into the tissues of the plant at the extremity of the compound maxillary stylet as explained above. When the chamber is emptied, the process is repeated as before.

As regards the function of the saliva I am not able at present to say anything definite. Meek (1903) remarks that the saliva of Hemiptera is alkaline, and has the power of changing starch into sugar. He refers to the work of Plateau (1874), 'Recherches sur les Phénonomène de la Digestion chez les Insectes,' who holds that primarily the saliva serves as a digestive fluid.

It may be, considering the extreme minuteness of the suction canal, that the ascent of the cell-sap along this canal is largely due to capillarity, and that the addition of the saliva causes the surface-tension of the sap to be lowered, thus facilitating its ascent up the suction-canal.

When suction is finished the pump-muscles and the protractor muscles of the stylets are relaxed, the stylets being withdrawn from the tissues of the plant by the contraction of the retractor muscles *md.re.*, *mx.re.* The integument at the posterior end of the buccal cavity is thin and flexible, thus allowing the stylets to be withdrawn for some distance into the head, into a kind of integumental sheath. The pull exerted on the tentorial arms by the retractor muscles is largely counteracted by the two elevator muscles of the transverse plate.

When the stylets are withdrawn from the plant the proboscis muscles are relaxed and that structure returns to its normal position of repose. Similarly the depressor muscles of the head pull the fore-head into its normal deflexed position.

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EXPLANATION OF THE PLATES.

Reference lettering.

a.d. Antero-dorsal arms of the tentorium.
a.v. Antero-ventral arms of the tentorium.
a.f. Thin chitinous fold joining forehead to epicranium.
ant. Antenna.
b.c. Buccal cavity.
b.f. Buccal fold.
c.ep. Stout chitinous mass formed at the beginning of the pharynx by junction of clypeal folds and internal walls of hypopharynx.
c.s.d. Common median salivary duct.
cl. Clypeus.
cl.f. Clypeal fold.
cl.l. Clypeo-labrum.
cl.sc. Clypeal sclerite.
conn. Œsophageal connective joining supra- and sub-œsophageal ganglia.
d.m. Divaricator muscles of pharynx.
e.c. Ejector canal (salivary) formed by meeting of maxillary stylets.
epc. Proximal part of head (epicranium).
ep. Epipharynx.
ep.gr. Longitudinal groove on epipharynx.
f.h. Ventral wall or floor of fore-head.
f.b. Fat-body cells.
g.o. Gustatory organ.
hs. Hypodermis.
hyp. Hypopharynx.
hyp.l. Hypopharynx lip.
lbr. Labrum.
lbm. Labium.
lbr.g. Longitudinal groove on labrum.
l.pr.g. Longitudinal groove on proboscis.
l.w. Thin post-lateral walls of head.
md. Mandibles.
md.l. Mandibular lever.
md.pr. Protractor muscles of mandibles.
md.re. Retractor muscles of mandibles, attached to antero-dorsal arms.
md'.re. Retractor muscles of mandibles, attached to transverse plate.
m.d.f. Depressor muscles of fore-head.
m.d.p. Elevator muscles of fore-head.
md.o. Retort-shaped organs of mandibles.
mx.s. Maxillary stylets.
mx.re. Retractor muscles of maxillary stylets, attached to transverse plate.
mx'.re. Retractor muscles of maxillary stylets, attached to antero-ventral arms.
mx.p. Maxillary processes.
mx.sc. Maxillary sclerite.
mx.l. Maxillary lever.
mx.f. Maxillary folds.
mx.sh. Integument of buccal cavity forming a sheath round stylets.
mx.o. Retort-shaped organs of maxillary stylets.
mx.pr. Protractor muscles of maxillary stylets.
m.t. Median vertical tendon to which the divaricator pharyngeal muscles are attached.
m.e.p. Elevator muscles of transverse plate.
œs. Œsophagus.
p.c. Pump-cylinder enclosing pump-chamber.
p.ch. Pump-chamber.
p.m. Pump-muscle.
p.w. Post-dorsal wall of clypeus (fore-head).
p.p. Pharynx protuberances.
p.v.w. Post-ventral border of fore-head.
ph. Pharynx.
ph.d. Pharyngeal duct leading from the suction-canal into pharynx proper.
ph.o. End of pharynx and beginning of œsophagus.
pr.w. Flexible proximal wall of labium.
pr. Labium (proboscis).
p.s. Pump-stem.

pst. Insertion of pump-muscle on the flexible proximal wall of salivary pump.
s.ga. Supra-œsophageal ganglion.
s.c. Suction-canal formed between the maxillary stylets and leading into pharyngeal duct.
s.e.d. Efferent salivary duct leading from salivary chamber into the salivary ejector-canal formed between the maxillary stylets.
s.p. Salivary pump.
s.gl.p. Posterior salivary gland.
t.p. Transverse chitinous plate of endoskeleton.
th.ga. Thoracic ganglia.
v.r. Ventral rods of chitin extending from posterior angles of the buccal folds.
v.m. Small ventral muscles of salivary pump, which act on the opening of the salivary duct into the pump-chamber.

Plate 24.

Fig. 1. Median longitudinal section through the head, slightly schematised, showing salivary pump, pharynx, etc. × 600. The indicating lines at the side indicate the plane through which the transverse serial sections figs. 4–22 have passed; the numbers refer to the number of the transverse section given. Figure drawn in outline from longitudinal section with Camera lucida.

2. Fore-head, ventral view, showing stylets, musculature, etc.—*Note.* The maxillary sclerites really come close together in the median line over the hypopharynx lip, but they are shown displaced from the median line so as to show the underlying hypopharynx lip. The lines at the side indicate the plane of the serial sections as in fig. 1. Figure drawn from potash preparation.

3. Fore-head, dorsal view, showing mandibles, musculature, and endoskeleton. Side-lines indicate as in fig. 1. Figure drawn from cleared preparation. The length is increased slightly out of proportion so as to show the antero-dorsal arms.

Figs. 4–11. Transverse sections through fore-head (*i. e.* at right angles to its longer axis), in planes indicated by side-lines in figs. 1–3. × 1245.

Fig. 23. Vertical section through fore-head, showing salivary pump and maxillary stylets. × 300.

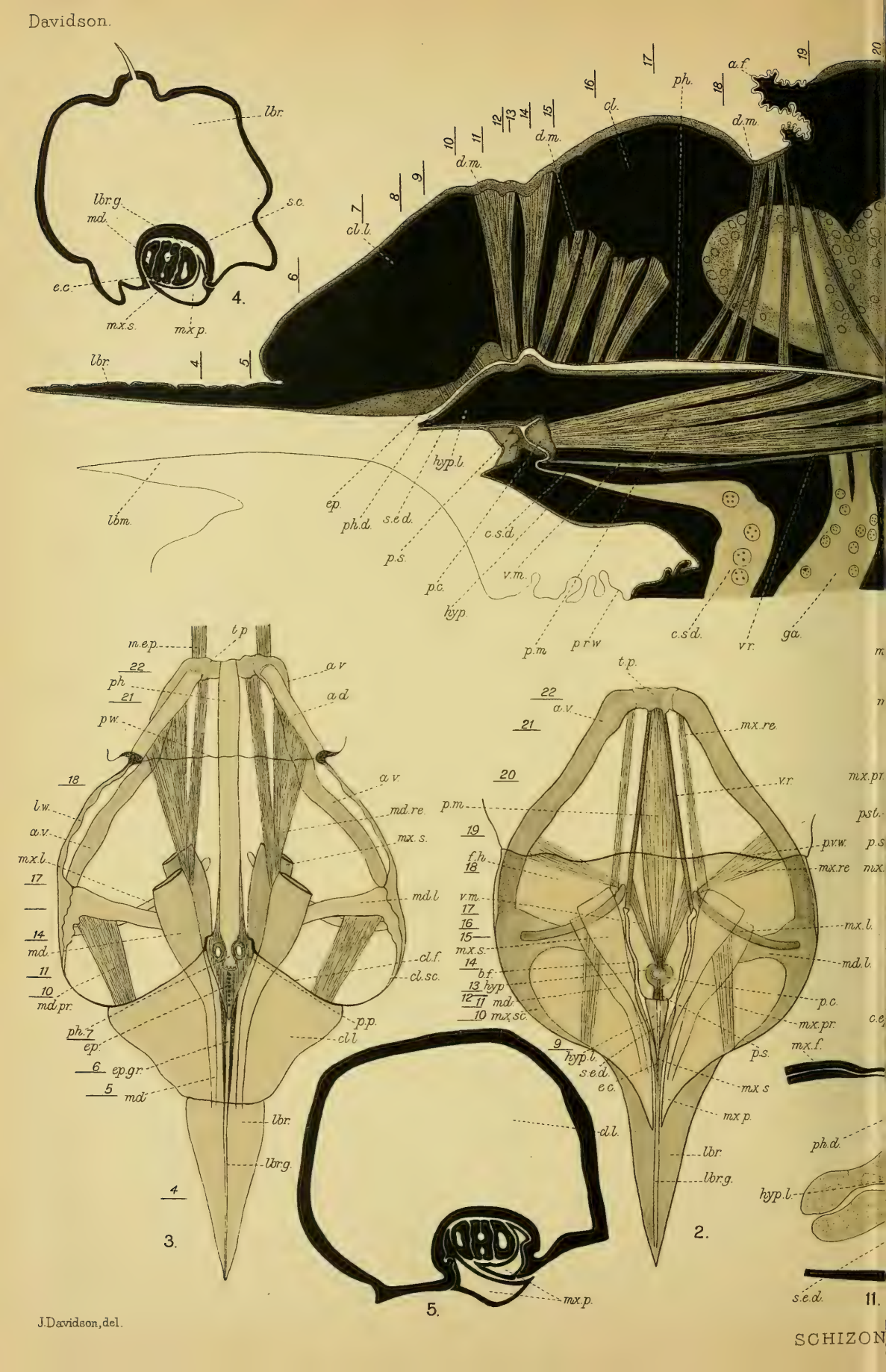
Plate 25.

Figs. 12–14. Continuation of the same series of transverse sections.

15–22. Transverse sections through fore-head in planes indicated by side-lines in figs. 1–3. Continuation of same series. × 450.

Fig. 24. (*a*) Extremity of compound maxillary stylet, showing two canals. × 1250.
(*b*) Extremity of mandible. × 1250.

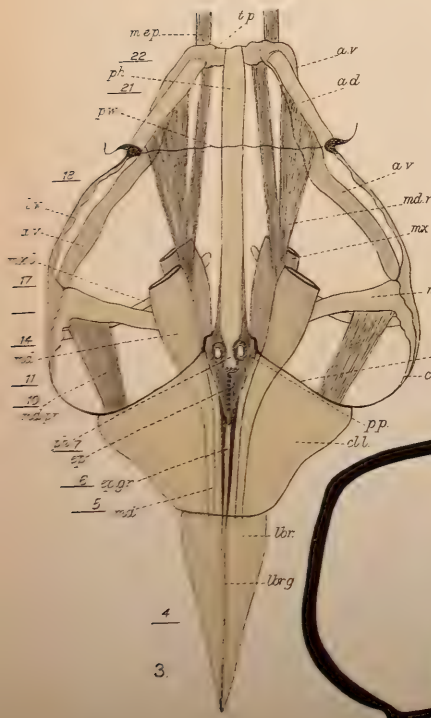
25. Longitudinal section, almost median, showing gustatory organ and its relation to perforated epipharynx. Stained with hæmatoxylin and orange G. × 450. The section is not quite median.

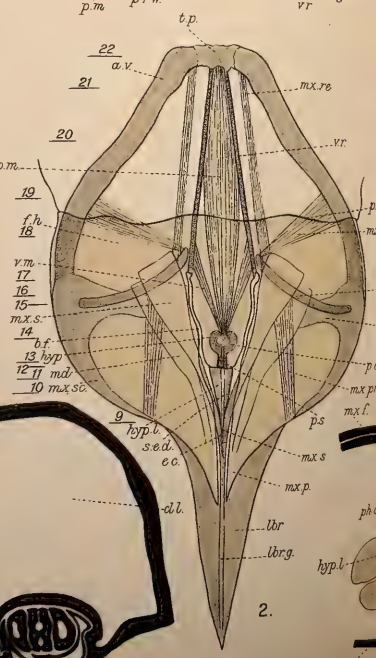


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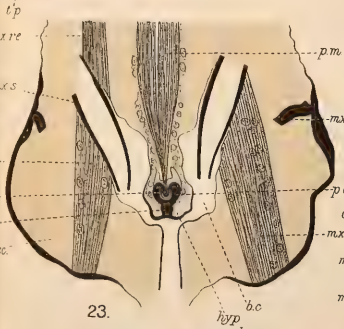
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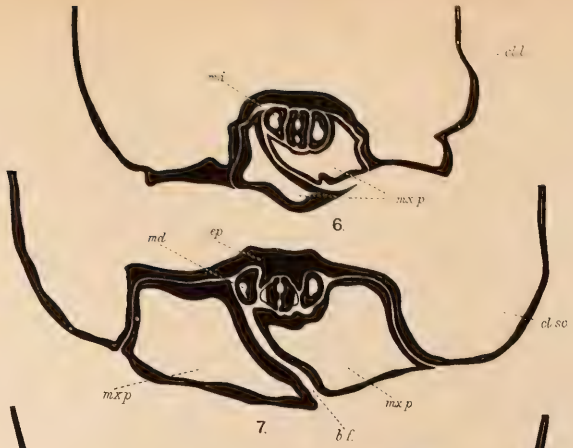




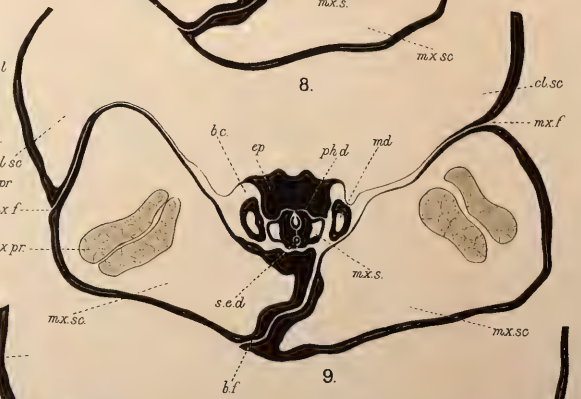


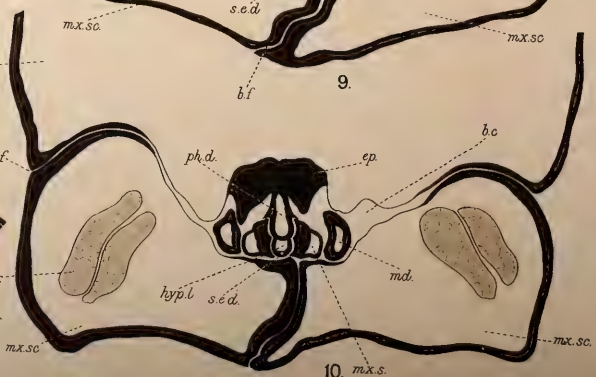












SCHIZONEURA LANIGERA.

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A New Amphipodan Genus and Species (Family Dexaminidæ) from New Zealand.

By Charles Chilton, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., Professor of Biology, Canterbury College, New Zealand.

(Plates 26 & 27.)

[Read 2nd April, 1914.]

The Amphipod described in this paper was taken on seaweed in rock-pools at Oamaru, on the East Coast of Otago, New Zealand, in June 1908, and from its bright red colour and conspicuous appearance was at once seen to be different from any of the Amphipoda so far described from New Zealand.

On examination, it proves to agree with the characters of the family Dexaminidæ as given by the Rev. T. R. R. Stebbing in 'Das Tierreich: Amphipoda,' except in the following points :—

(1) The second joint of the peduncle of the upper antenna is not specially long.

(2) The inner lobe of the second maxilla is sparsely fringed with setæ along the greater part of its inner margin as well as at the extremity.

Probably neither of these points is of sufficient importance to be included in the diagnosis of the family. The second joint of the peduncle of the upper antenna varies considerably in length in different specimens of the species *Paradexamine pacifica* (G. M. Thomson) (see Chilton, 1912, p. 502); in *P. flindersi* (Stebbing) (1910, p. 603) it is slightly shorter than the first segment, and should perhaps not therefore be called long, and similarly in *Guernea coalita* (Norman) it is shorter than the first which is described as "not much longer than the second" (Stebbing, 1906, p. 522). The second character also does not hold for all species of the family. Chevreux (1913, p. 181) has pointed out that in the species named by him *Paradexamine fissicauda* the inner lobe of the second maxilla has its inner margin fringed with setæ ; I found this also to be the case with specimens from the South Orkneys, collected by the "Scotia" Expedition, which I (1912, p. 502) referred to *P. pacifica* (G. M. Thomson), a species from which I consider *P. fissicauda* to be hardly distinct; in New Zealand specimens of *P. pacifica*, however, the setæ are almost confined to the extremity. In *Polycheria antarctica* (Stebbing) there are a few setæ on the inner margin of the inner plate (Stebbing, 1906, p. 520).

I have found it impossible to refer the species described below to any of the existing genera of the Dexaminidæ. According to the characters given in the "Synopsis of Genera" by Stebbing (1906, p. 514), it would have to come

near to *Paradexamine*, but it differs distinctly from that genus in the character of the mandible, which shows no dentate cutting-edge, spine-row, nor distinguishable molar, and therefore appears to be similar to the mandible of *Guernea*, a genus distinguished from *Paradexamine* by the two-jointed palp of the first maxilla, and by other characters.

In the lower lip, again, my species resembles *Guernea coalita* (Norman) in having the principal lobes with an acute apex and the mandibular processes obsolete. There seems to be some approach to this character in *Paradexamine*, for in describing *P. fissicauda*, Chevreux (1906, p. 90) says "Les lobes latéraux de la lèvre postérieure portent une petite dent au bord interne." This little tooth, however, seems to be rather different from the acute apex to the lobe in the species described below; in a dissection of one of the specimens of the *Paradexamine* from the South Orkneys (mentioned above), there is on one side a tooth, apparently as figured by Chevreux, it is narrow and stands out like a little tooth or process from the general outline of the lobe, and there is a smaller and shorter process situated more proximally on the inner margin; on the other side of the appendage this second process is present, but the other, nearer the apex of the lobe, is not apparent in the preparation.

I have, therefore, decided to establish for my species a new genus, which I propose to name *Syndexamine*, and which may be defined as follows :—

SYNDEXAMINE, nov. gen.

Upper antenna longer than the lower; palp of the maxillipeds four-jointed; lower lip with inner lobes well-developed, principal lobes with an acute apex; mandibular processes obsolete; mandibles with cutting-edge rounded and entire, no apparent spine-row, nor definite molar; palp of first maxilla one-jointed. In other characters, similar on the whole to *Paradexamine*.

SYNDEXAMINE CARINATA, sp. nov. (Plates 26 & 27.)

Specific description :—Peræon robust, dorsally rounded anteriorly, laterally compressed and slightly carinate in the last one or two segments. Pleon carinate, segments 1 to 3 each produced dorsally into a strong keel ending posteriorly subacutely; segment 4 with a dorsal keel on posterior part of the segment, the dorsal margin of the keel dorsally rounded in front and ending somewhat acutely behind. None of the segments of peræon or pleon produced into dorsal or lateral teeth. Head slightly longer than the first and second segments of the peræon combined; dorsal surface convex so that the anterior part is depressed; rostrum very short and blunt at apex. Pleon segment 3 with postero-lateral angle acute and slightly produced; the combined 5th and 6th segments bearing a group of three or four stout spinules at the base of the telson, and one lateral spinule more anteriorly and

in a line with the single spinule on the 4th segment. Eye of moderate size, of many facets, rounded or slightly oval. Side plates 1–4 of about equal depths, not so deep as their respective segments ; the anterior lobe of the 5th side plate small ; 6th and 7th side plates subquadrangular with posterior margins rounded.

Upper antenna about two-thirds as long as the body, much longer than the lower antenna ; peduncle with first joint stout, bearing below numerous strong spines, second segment about two-thirds the length of the first with a group of three stout spines on lower surface about one-third the length from the base, third segment short, nearly similar to the joints of the flagellum ; flagellum more than twice as long as the peduncle and of many joints. Antenna 2 with fourth joint much the longest, armed above and below with stout spinules, fifth joint less than half as long as the fourth ; flagellum many-jointed, longer than peduncle. First and second gnathopods equal in size and similar in shape, carpus about as long and broad as propod ; the latter ovoid with the palm oblique, straight or slightly concave, defined by one or two stout spinules. All the peræopoda with the dactyl particularly strong and bent back upon the propod, which bears three groups of stout spines, the whole forming an effective grasping organ. Third uropod reaching beyond the end of the second uropod and of the telson, its two branches broadly lanceolate, each with both margins armed with stout spinules. Telson narrowing distally, cleft for rather more than two-thirds its length, each lobe with a stout spinule at the end and two or three on the lateral margin.

Colour.—Bright red, eyes red.

Length of largest specimen (in position in which it is drawn) 9 mm.

Hab. Oamaru, on East Coast of South Island of New Zealand, four specimens ; one small immature specimen from Lyttelton Harbour.

General Description.

In most of the characters this species presents a fairly close resemblance to species of *Dexamine* and *Paradexamine*, though, as seen from the generic description, it combines characters belonging to different genera. The general shape and carination of the body is not unlike that of *D. spinosa* (except that none of the segments is produced into teeth), while the carina on the fourth pleon segment is almost the same in outline as that of *D. spiniventris* (A. Costa). The integument seems particularly hard and firm. I give the following general description of the different appendages for comparison with other species.

The *upper antenna* (Plate 26. fig. 2) is about two-thirds the length of the body, and has the first joint longer and broader than the second and fringed with about a dozen stout spinules on the distal half of the lower margin ; the second joint has a group of three similar spinules about one-third its length

from the base on the lower margin, and one or two small setæ placed more distally ; the third joint is small and hardly differs from the first segment of the flagellum which is long, containing about 40 joints.

The *lower antenna* (fig. 3) is much shorter than the upper and has the penultimate joint of the peduncle longer than any of the others and provided with groups of spines on both upper and lower margins ; the last joint of the peduncle is not much more than a third the length of the preceding one and bears only two small setæ at the distal end ; the flagellum is much longer than the peduncle and contains about 25 joints.

The *upper lip* (fig. 4) is of the normal form, with its free surface regularly convex and bearing a few short setæ.

The *mandible* (fig. 5) differs very greatly from that of *Dexamine* or *Paradexamine*, but appears to be similar to that of *Guernea coalita* (Norman) as described and figured by Della Valle (1893, p. 570) : there is no palp, the part corresponding to the cutting-edge is strongly chitinised but is destitute of teeth and has the margin quite entire. There is no appearance of a spine-row nor of a molar; there is a small rounded protuberance which may possibly represent the accessory plate, but this has rounded entire margins without any appearance of teeth. The right and left mandibles appear to be similar.

The *lower lip* (fig. 6) appears to be similar to that of *Guernea*, the inner lobes being fairly well developed and apparently somewhat irregularly lobed at the extremities; the principal lobes end in a small acute process which seems to be thin and delicate, the outer margins are rounded and there are no mandibular processes.

In the *first maxilla* (fig. 7) the inner lobe is small and bears two setæ, the outer lobe bears about a dozen strong spines most of which are more or less dentate ; the palp consists of one joint only, fairly broad, appearing to have the same shape in both maxillæ, and fringed with setæ at the extremity and along the distal portion of the inner margin.

The *second maxilla* (fig. 8) has the inner lobe shorter and narrower than the outer, with setæ along the greater part of its inner margin, but more numerous towards the extremity.

In the *maxillipeds* (fig. 9) the inner plate is small, rectangular, ending in a few long setæ. The outer plate is large but does not reach quite to the end of the palp. Its inner margin bears numerous stout spines which become longer towards the extremity and gradually pass into the more slender setæ on the extremity and distal portion of the outer margin; the palp consists of four joints of the usual shape, the terminal one being quite small but distinct.

The *first gnathopods* (Plate 27. fig. 10) have the basal joint long and bearing numerous long setæ near its anterior margin ; the carpus is fully as long as the propod, widens distally and bears three distinct tufts of stout

setæ and a few smaller ones on the posterior margin, and a group of long setæ at the antero-distal angle; the propod is slightly narrower at the base than the carpus, it narrows distally and has the palm oblique, straight, or slightly concave, defined by two stout spines, and fringed with slender setæ, on the anterior margin there are three obliquely transverse rows of setæ and along the centre of the lateral surface a long row of short setæ. The arrangement of the setæ on the propod is practically the same as that in *Paradexamine pacifica* (G. M. Thomson).

The *second gnathopod* is almost identical in size and form with the first.

The *first peræopod* (fig. 11) has the side plate convex in front and slightly concave behind, the limb is short and stout, the carpus less than half as long as the propod, the dactyl particularly strong, about two-thirds as long as the propod and bent back upon it so as to form with the three groups of spines on the propod a very efficient grasping organ.

The *second peræopod* (fig. 12) is similar but has the side plate broader and produced at the lower posterior angle into a broad rounded lobe.

The *third peræopod* (fig. 13) is considerably longer than the preceding one, its side-plate has the anterior lobe produced downwards below the posterior lobe which bears two or three small spines on its lower margin, the second joint is moderately broad, its anterior margin slightly convex and bearing six groups of short stout spines, posterior margin nearly straight and without spines; carpus shorter than the propod; the latter and the dactyl are similar to those of the preceding peræopoda.

The *fourth peræopod* (fig. 14) is similar to the third but slightly longer and has the posterior margin of the second joint slightly convex.

The *fifth peræopod* (fig. 15) is similar to the preceding, but has the second joint narrower and its posterior margin slightly concave.

The *uropoda* (figs. 16, 17, 18, 18 *a*) are similar in character to those found in other species of the Dexaminidæ, the first pair reaches a little beyond the extremity of the second and as far as the end of the third, the end of the second uropoda being on the level with the end of the telson. The proportions of the peduncles and their rami and the arrangement of the spines thereon will be best learnt from the figures; in the third uropoda (figs. 18 & 18 *a*) there is a group of stout spines at the distal end of the upper margin of the peduncle; the two rami are lanceolate and end acutely in the usual manner, and bear numerous spines on each margin.

The *telson* (fig. 19) has the normal shape, it is cleft for more than two-thirds of its length, narrows greatly towards the extremity, each lobe has a stout spine at the end and two or three similar spines at the lateral margin; in the specimen figured there are three on one side and only two on the other.

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EXPLANATION OF THE PLATES.

Plate 26.

Syndexamine carinata, nov. gen. et sp.

Fig. 1. Side view of whole animal, × about 10 times.
2. Upper antenna.
3. Lower antenna.
4. Upper lip.
5. Mandible.
6. Lower lip.
7. First maxilla.
8. Second maxilla.
9. Maxilliped.

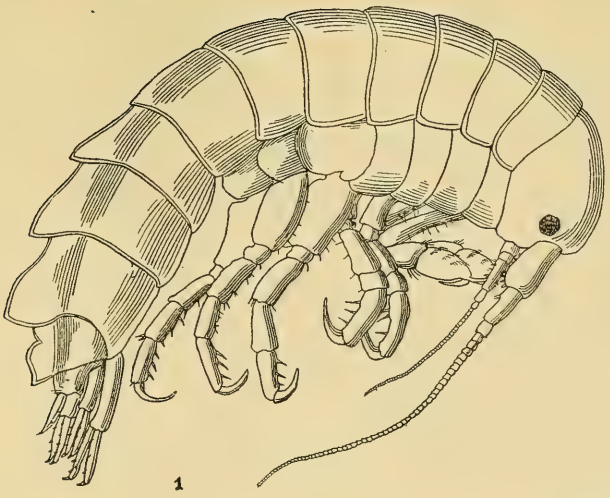
(All the mouth-parts are drawn to the same scale, the antennæ are less highly magnified.)

Plate 27.

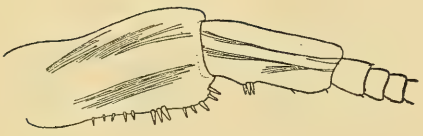
Syndexamine carinata, nov. gen. et sp.

Fig. 10. First gnathopod.
11. First peræopod.
12. Second peræopod.
13. Third peræopod.
14. Fourth peræopod.
15. Fifth peræopod.
16. First uropod.
17. Second uropod.
18. Third uropod. (Side view.)
18 *a*. Third uropod. (Seen from above.)
19. Telson.

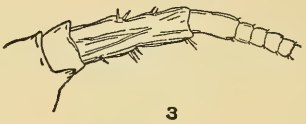
(The peræopods are all drawn to the same scale, and are less highly magnified than the first gnathopod and the uropods and telson.)



1



2



3



4



5



8



6



7

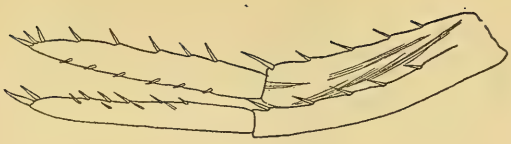


9

C. C. del.

Grout sc. & imp.

SYNDEXAMINE CARINATA nov. gen. et. sp.



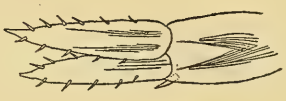
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18



17



18A



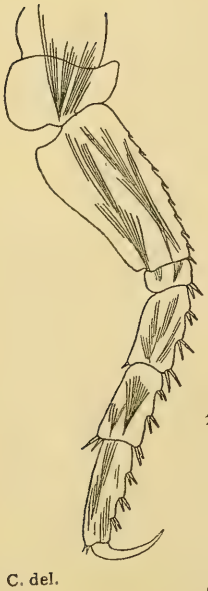
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11



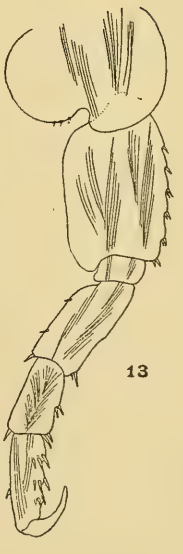
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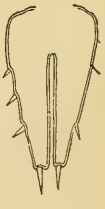
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14



13



19

C. C. del.

Grout sc. & imp.

SYNDEXAMINE CARINATA nov. gen. et. sp.

Results of Crossing *Euschistus variolarius* and *Euschistus servus* with reference to the Inheritance of an Exclusively Male Character.

By Katharine Foot and E. C. Strobell. (Communicated by Prof. E. B. Poulton, F.R.S., Pres.L.S.)

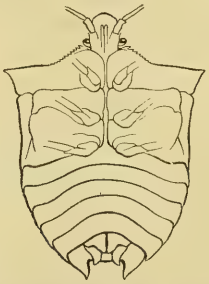
(Plates 28–34, and 2 Text-figures.)

[Read 5th March, 1914.]

Euschistus variolarius has an exclusively male character which is not present in *Euschistus servus*, and it was the hope of being able to study the transmission of this character, and its bearing on modern chromosome theories, that led us to attempt to cross these two species *.

This specific character is a distinct black spot on the male genital segment of *E. variolarius*, and as there is no spot on the genital segment of the female (text-fig. 1), this spot in *E. variolarius* is an exclusively male character.

Fig. 1.



Euschistus variolarius ♀. A comparison of this sketch with the male *variolarius* of photo 1 (Pl. 28.), will show the marked difference in the form of the genital segment of the two sexes, and will demonstrate that the genital spot characteristic of the male could not appear in the female without a modification of the entire genital segment.

The two species (*variolarius* and *servus*) are shown in photo 1 (Pl. 28). On the left is a male *variolarius*, and on the right a male *servus*. The spot on the male genital segment of *variolarius* is clearly demonstrated, and the complete absence of such a spot on the male genital segment of *servus* is clearly shown. This spot in *variolarius* is a constant character : it appears as distinctly in all the males of this species as in the seven specimens shown in photo 2. Five male specimens of *E. servus* are shown in photo 3 (Pl. 30).

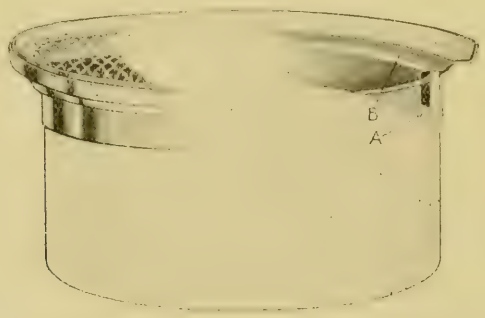
The difficulties involved in raising Hemiptera in captivity are serious. For five consecutive summers we have experimented raising several species

* The *E. variolarius* ♀ used for the cross-breeding experiments was raised in our laboratory from material we collected at Ridgefield, Connecticut, and the *E. servus* were collected at Southern Pines, North Carolina, by Rev. A. H. Manee.

in our laboratory, aiming to learn to raise these bugs with as low a death-rate as possible, and it was not until after three years of experimenting that we felt it would be safe to attempt to cross two or more of these species. The three most troublesome problems in this work were to provide the proper food, to use cages well adapted for cleanliness and observation, and to maintain the right degree of moisture. The bugs must have not only abundant food, but it must be fresh and clean, and these conditions can be successfully met only by frequently transferring the insects to clean cages with fresh food. This should be done at least every third day, or, better still, every second day. We were forced to do this work ourselves, for raising the nymphs demands such delicate care that we were unable to entrust it to an assistant. It proved to be an arduous task during part of the breeding season, when, in our experiments, we found it necessary to change the food for more than 30 cages each day.

The cages we used for the adult bugs were glass dishes about 6 inches in diameter and 3 inches deep. The covers were of coarse brass wire mesh, carefully designed to prevent the possibility of the tarsi of the bugs being caught at any point where the brass cover comes in contact with the glass dish (text-fig. 2). Until we were able to design these covers the bugs were

Fig. 2.



Cage designed to prevent the insects from catching the tarsi at the point of contact between the glass dish and the metal top. The spaces marked A and B are large enough to allow the legs to move about freely, but are too small to admit any part of the body.

frequently mutilated, for if the tarsus is caught, the entire leg of the bug is sacrificed, for the leg always gives way at the proximal end of the femur.

Such mutilation apparently does not seriously interfere with the functional activity of the bugs, for in one case a female that had lost three legs continued to mate and lay eggs quite normally. The greatest danger lies in the fact that a bug in this mutilated condition cannot always regain its normal position if it has, by chance, dropped on its back, for in this position even the adult bugs frequently die in a few hours.

The food chosen for our experiments was wheat and orchard grass while

they lasted, and later in the season timothy heads and berries. The former were placed in the cage in two small bunches, each containing not more than five heads, cut to about 3 inches in length and the stems tightly wrapped together in wet absorbent cotton. If the cotton is kept wet, the food will keep quite fresh for three days.

When blackberries were used, they were not plucked from the stems, but small sprays with berries were selected, cut in lengths of 3 inches, and the stems wrapped in wet cotton. All the leaves were carefully trimmed from each spray, and only one large, or two small sprays were used in each cage. The leaves must be cut off because they hide the bugs, and they are of no value as food—becoming dry in a few hours. It is very important to place the food in the cages in such a way that every bug can be seen at any time and closely watched. When we used strawberries or cherries, we suspended them by their stems from the wire tops of the cage. Frequently we used the tips of young milk-weed, for we found that the bugs in captivity often deposit their eggs on the under side of these leaves, though we have never found any deposited on milk-weed in nature. In order to be sure that all the eggs of our experiments were deposited by the bugs we had under observation, no fresh food was ever placed in the cages without being carefully examined to be sure that no eggs of a kindred species were by any chance brought into the cages. If, however, the food is changed every third day, this danger is practically eliminated, for the eggs of this species require only from 5 to 7 days to hatch, and unless any alien eggs were deposited on the food the same day it was put in the cage, such a mistake would be very readily detected. This particular risk to our experiments was reduced to a minimum in the season of 1912, for the locality where we spent the summer was not only an unfavourable one for Hemiptera, but the exceptional cold of the preceding winter had made the locality even more than usually unfavourable. During the entire summer we succeeded in finding only two specimens of *Euschistus variolarius*, though we constantly searched the wheat fields, berry bushes, &c.

If the food is properly placed in the cages, the bugs can be kept under constant observation. We have frequently watched them deposit their eggs, and were able to note approximately the length of time of each mating. The number of bugs in each cage must necessarily be limited, or accurate observation is impossible. As a rule we never placed more than four pairs in a cage, and as soon as a pair was found mating, they were transferred at once to a separate cage, in which they were kept isolated for the entire breeding season. Thus, for the important experiments, a single pair of bugs was confined in one cage, and each mating and the deposition of each batch of eggs could be accurately noted.

The cages suitable for the adult bugs are of course not suitable for the larval stages, unless a much finer wire mesh is used for the cover. After various experiments we found wet chamber dishes the most satisfactory

cage for the nymphs, care being taken to select a size deep enough for the food and large enough to hold from 20 to 30 nymphs without overcrowding. Sometimes as many as 30 nymphs are hatched from a single batch of eggs, and these may be very active after the first moult. We selected wet chamber dishes, about 120 mm. in diameter and 25 mm. deep. Experiments proved that the nymphs have sufficient air in these dishes, and can be raised with safety through the five moults to the winged stage.

The food suitable for the adult bugs is not satisfactory for the larval stages. Until after the third moult the nymphs are so small that they hide under the petals of the berries and in the grasses, and it requires too much time and patience to find them. The most satisfactory food for these stages proved to be the small, tender leaves that form the centre of headed lettuce. Experiment showed that the nymphs often select these leaves in preference to the berries, and they certainly develop most satisfactorily on this food, through the five moults to the winged stage. During the height of the breeding season we used 15 heads of lettuce a day, as the nymphs were transferred to a clean cage and fresh lettuce every other day. In making this transfer the cage containing the nymphs was carried to a separate table, used only for this purpose. The clean cage, labelled and containing fresh lettuce leaves, was placed on the same table, and the nymphs were carefully lifted from each stale leaf of lettuce to the fresh cage by using a very fine camel's hair brush. The nymphs were carefully counted while moving them from one cage to another, and it very rarely happened that a nymph was accidentally thrown away with the discarded lettuce.

To keep the proper degree of moisture in the cages proved to be a very troublesome problem. A certain amount of moisture is necessary to preserve the food, but if the cotton which is wrapped around the stems of the wheat, &c., is too wet, some of the water may drop on to the glass bottom of the cage, and if a bug falls on its back in even a few drops of water, it frequently cannot regain its normal position, and may die in a few hours. This danger must be controlled, for bugs frequently drop from the top or sides of the cage, and from the food. Too much moisture is even more dangerous for the larval stages. The drops that collect on the inner surface of the glass cover of the wet chamber dishes and fall to the bottom of the dish, mean death to any nymphs that may fall on their backs into even one drop of moisture. It requires constant vigilance to avoid this danger, by frequently wiping off the moisture that collects on the inside of the glass cover. We tried to avoid this risk by placing ordinary filter-paper on the bottom of the cages, but this did not work well, for the tarsi of the bugs frequently caught in the fibres of this coarse paper. But by substituting the German hardened filter-paper for the coarser paper, we got rid of this difficulty. The filter-paper must be cut to fit the bottom of the cages exactly, and it must be kept moist, but not too wet, for too much moisture will rot the delicate lettuce leaves. We have frequently watched the adult bugs, and

also the nymphs, suck the water from this filter-paper, but apparently with no injurious after-effects. We aimed to keep the temperature at 80° Fahr. night and day, and we succeeded in keeping the heat quite constantly at this point by using an electric stove.

It requires unremitting care to raise these Hemiptera in the laboratory. They not only require constant watching during the day, but must be examined two or three times in the night. Not only is this necessary for accurate observations, but if the adults or nymphs are found on their backs, they can be turned over with a camel's hair brush and their lives thus saved.

All our records have been kept with the utmost care. We have recorded not only the number and date of the deposition of the eggs, but the date of hatching, the number hatched in each group, the date when each of the five moults occurred, and a record of just how many young survived each moult. This is very important, in order to know the exact number of nymphs in each wet chamber dish, and thus avoid the danger of unwittingly throwing away a nymph with the stale food. As a rule, the nymphs from a single batch of eggs were kept separate, but late in the season, when only a few nymphs hatched out from a group of eggs, these nymphs, after the 1st or 2nd moult, were added to a cage that contained other nymphs from the same parents. When possible the date and hour of the deposition of each batch of eggs was recorded, though this of course was only possible where the deposition of the eggs was actually observed. In all other cases the time given is only approximate; but as the food in the cages was arranged to expose to view the places generally selected by the bugs for depositing their eggs, they were not often overlooked, until the food was changed and a closer search was possible. It is very important to secure the eggs as soon as possible after they are laid, for we found that both the male and the female parents will occasionally suck the eggs. Sometimes the male and sometimes the female was found with the proboscis buried in one of the eggs, very busy sucking out the entire contents. They pass from one egg to the next and may destroy a large number of eggs, leaving only transparent empty shells.

Two sets of records were kept for each pair of bugs, one set recording the history of the parents, and the second set recording the development of their offspring.

A full copy of these notes would make too voluminous a record to be published here, but in order to compare the breeding habits of *variolarius*, *servus*, the crosses and the F_1 hybrids, we shall give a condensed extract from these notes, showing for some individual cases, the number of eggs deposited by one female, the relative number that hatched, and the relation between mating and the deposition of eggs. Records I.–XI. pp. 362–70.

We have frequently watched the hatching of the eggs and the subsequent five moults of the nymphs before they reach the winged stage. Nymphs from the same group of eggs that hatched the same day, or even the same

hour, grow very unequally, occasionally a few of them being so retarded that they have reached only the third moult at the time the others have completed the fifth moult. Nymphs showing such greatly retarded development almost invariably die.

Details of Crossing *Euschistus variolarius* ♀ × *Euschistus servus* ♂.

In November 1911, we placed in the same cage three female *variolarius* and five male *servus*, all of which had recently passed the fifth moult. These eight specimens were kept together throughout the following winter. In the spring (May 3rd) one of these *variolarius* females mated with one of the male *servus*, this demonstrating the possibility of crossing these two species. This female *variolarius* was hatched in our laboratory September 11th, 1911. The month before we had collected a few wild specimens of *variolarius* in Ridgefield, Connecticut, in order to secure young, vigorous bugs to carry through the winter for our crossing experiments, and eggs were deposited several times in this cage. It was from one of these groups of eggs that we secured the three females we used for crossing with *servus*. There were 17 eggs in this group, but only seven of them hatched, this being due, undoubtedly, to their having been deposited so late in the season. Six of these seven nymphs—2 males and 4 females—were reared to the winged stage, the 5th moult not being completed until October 16th. Three of these four *variolarius* females were selected to cage with *servus*, and the two *variolarius* males were killed the fourth day after the fifth moult, and preserved in alcohol, in order to avoid the possibility of any question being raised as to the identification of the females as pure *variolarius*. One of these two males is shown on Pl. **28**, photo 6, and the black genital spot, distinctive of the species *variolarius*, is clearly shown. We believe we gained a great advantage by selecting bugs that hatched out so late in the season, for females which reach the winged stage so late as the middle of October are sure to remain all winter as vigorous sexually immature bugs, thus offering the best possible chance for successful breeding experiments in the spring.

The five male *servus* that were kept through the winter with the three female *variolarius*, were hatched from eggs deposited in our laboratory by a female *servus* received from North Carolina the day before the eggs were laid. A group of 10 eggs was deposited September 17th ; 9 of these hatched and 8 were reared to the winged stage, the 5th moult being completed October 28th. Five of these bugs were males, and three females. On November 3rd the five males were added to the cage which contained the three above-mentioned female *variolarius*. In the further description of this cross, this cage will be designated as Cage 2. None of these bugs mated until May 3rd when, as stated above, one pair mated 7 hours (see Record III. p. 364).

As none of these bugs had mated again by May 26th, and the males seemed less vigorous than some wild specimens we had received from North Carolina two days before, we decided to take the five male *servus* from Cage 2, and replace them with three of the wild specimens just received from North Carolina. Three of the five male *servus* that were taken from Cage 2 at this time are shown on Pl. 28. photo 5, and as all five came from the same batch of eggs, these three specimens will serve to demonstrate the species. Each of the three males selected from the wild specimens (to replace the five that were raised in the laboratory) had just mated for several hours with its own species. One was put in Cage 2 May 26th, one on May 27th, and one on May 28th. The next morning at 5 o'clock a pair was found mating, but they separated before we could isolate them. Later in the same day the same female and, probably, the same male mated again. They were then isolated by being left in Cage 2, while the remaining bugs were transferred to another cage. They were kept isolated in Cage 2 until the female died July 16th.

Before the breeding season commenced, one of the three original female *variolarius* had unfortunately been thrown away with the stale food, and we were therefore left with only two of the three original females. One of these was undersize and never mated, though she was in a cage for nearly a month with several wild male *servus*.

We succeeded therefore in crossing only one female *variolarius* with *servus*; but this proved to be a fortunate circumstance, for this pair was sufficiently fertile to give us all the F_1 and F_2 hybrids that we could possibly care for, as at the same time we were raising hybrids from a cross between *E. variolarius* ♀ and *E. ictericus* ♂.

The female *variolarius* and the male *servus* in Cage 2 mated again June 11th: they mated 51 hours. This was the last time this pair mated, though the female deposited eggs six times after this mating, while normally eggs are deposited only once or twice between two matings.

In order to compare the breeding habits of this cross and of the F_1 hybrids, with the breeding habits of pure *variolarius* and *servus* we will give a brief summary of the data we have collected from our laboratory experiments.

A more detailed account of some of these experiments is given on pp. 362–70, where we have reproduced extracts from our records of eleven pairs of bugs that were isolated through their entire breeding period. All our experiments with *variolarius* and with *servus* indicate that they are alike in certain details of their breeding habits. Records I. & II., pp. 362–3, give what we believe to be the normal breeding habits of both these species. These records show the approximate number of eggs deposited by one female during the breeding season, the approximate intervals of time between the deposition of eggs, the frequency of the matings, and their approximate duration. They show

that mating occurs during the breeding season at rather definite intervals in relation to the deposition of eggs, as a rule eggs being deposited only once or twice between two matings. These records show further that nearly all the eggs deposited during the height of the breeding season develop and hatch. The features in which the breeding habits of the crosses differ from the normal can be best appreciated by comparing the following brief summary of the results from the eleven records given on pp. 362–70.

Record I. (p. 362). *E. variolarius* (one pair).—210 eggs were deposited from May 22nd to August 25th. The pair mated 13 times, and eggs were deposited 9 times, but not oftener than once or twice between two matings. None of the eggs deposited after July 25th were kept. Of the 129 eggs deposited before that date all hatched except seven, which were undoubtedly injured by the male, for he was discovered sucking them almost immediately after they had been deposited. He had taken the entire contents from two of these eggs, leaving nothing but the transparent shells.

Record II. (p. 363). *E. variolarius* (one pair).—78 eggs were deposited between July 2nd and July 26th. The pair mated 12 times, and eggs were deposited 6 times,—in one instance being deposited 3 times between two matings. None of the eggs deposited after July 10th were kept. Of the 63 deposited before that date all hatched but three. This pair was killed July 26th.

The two records (I. & II.) show what we believe to be the normal breeding habit of both *E. variolarius* and *E. servus*. They show that nearly all eggs develop that are deposited during the height of the breeding season, and that mating occurs oftener than eggs are deposited. They show further that, as a rule, eggs are deposited not oftener than once or twice between two matings. In these three features the crosses vary greatly from the normal, for a very small percentage of the hybrid eggs develop, and mating is very rare. They are, however, quite normal as to the number of eggs deposited, and the intervals of their deposition. The difference between normal breeding and the cross, is shown by the following summary of Record III.

Record III. (p. 364). *E. variolarius* ♀ × *E. servus* ♂.—120 eggs were deposited from May 23rd to July 9th. This is quite the normal number, but an abnormally small proportion of these eggs developed. 83 showed no signs of any development, and were probably unfertilized. Five showed the initial stages of development, but failed to hatch, and only 32 of the 120 eggs developed to the point of hatching. Further, the deposition of many of these eggs was abnormal. They were frequently deposited in small irregular groups, such as those deposited by isolated females that have never mated.

For more than a month during the height of the breeding season—

June 11th to July 16th—this pair did not mate, and during this period eggs were deposited six times, whereas normally eggs are deposited only once or twice between two matings. This female deposited eggs 20 times, and mated only 4 times, whereas normally mating occurs more frequently than the deposition of eggs. These facts suggest that a more normal proportion of the hybrid eggs might have been developed if the matings had been normal. Whatever condition exists that interferes with the mating of these two species, it is evidently not due to the fact that either the male or the female was functionally inactive, for the female deposited the normal number of eggs at normal intervals, and the male, when temporarily transferred July 2nd to a cage containing three female *servus*, mated the same day with one of his own species, and continued to mate for 42 hours. Further, he had mated with his own species before being caged with the female *variolarius*. July 2nd, we placed a few fresh wild *servus* males in Cage 2, but the *variolarius* female did not mate again, and died, July 16th.

Of the 32 F. 1 hybrid nymphs from this pair, 27 were reared to the winged stage (11 ♂ & 16 ♀). We have photographs of all these eleven males, and ten of them are reproduced on Plate **28**, photos 7 to 14.

There is a marked similarity between the abnormal features of this cross and those of a cross between an F_1 hybrid female and a pure *variolarius* male. To compare the breeding of these two crosses we will give, at this point, a brief summary of the results from Record XI.

Record XI. (p. 370). F_1 *Hybrid* ♀ × *Pure variolarius* ♂.—119 eggs were deposited between August 25th and September 18th. Only 36 of these hatched. Eggs were deposited 12 times and mating occurred only once. This pair did not mate a second time, though they were caged through their entire breeding period, which, in this case, did not begin until August 22nd *.

The two crosses of Records III. and XI. resemble each other in the fact that the mating of neither pair was normal, and that an abnormally small proportion of their eggs hatched. They are unlike, however, in that almost a normal proportion of the eggs of the cross of Record XI. showed the initial stages of development. The development, however, was obviously abnormal, and many of these eggs failed to hatch. Of the 36 eggs that hatched, 26 were reared to the winged stage (18 ♂ & 8 ♀). All the males were photographed, and are shown on Plate **34**, photos 62–66. The pure *variolarius* male of this cross is shown on Plate **34**, photo 58.

* In this connection it is interesting to note that an F_1 hybrid ♀ (from *variolarius* ♀ × *ictericus* ♂) that was caged with a pure *ictericus* ♂, mated normally through the entire breeding season. The female, however, had been kept through the winter, and they mated for the first time June 15th.

F_1 *Hybrids.*—Thirty-two of this generation were hatched (see Record III. p. 364) and 27 were safely reared through the five moults to the winged stage. They hatched between June 4th and July 9th, and reached the winged stage between July 8th and August 3rd.

As soon as they reached the winged stage (*i. e.* after the 5th moult) they were transferred to a large cage and closely watched. As each pair mated, they were isolated, while mating, to a separate cage, and kept isolated throughout the entire breeding period. The eggs from these F. 1 pairs were placed in wet chamber dishes as soon as they were deposited, and the F. 2 nymphs were carried through their entire development in these dishes, until they reached the winged stage, when they were killed and preserved in glycerine, as described on p. 371.

On July 9th and 10th, seven of the F_1 hybrid nymphs reached the winged stage (3 ♀ & 4 ♂). On July 19th two of these F_1 hybrid pairs mated, each pair being transferred at once to a separate cage while mating. They were kept thus isolated through their entire breeding season (see Records IV. and V., pp. 364–5). In this manner we isolated seven pairs of these F_1 hybrids.

Records IV. to X. give the details of these breeding experiments, and a brief summary of the results will show what features are typical of this generation of F_1 hybrids.

Record IV. (p. 364). *First Pair of* F_1 *Hybrids.*—169 eggs were deposited from August 2nd to August 31st. The pair mated 14 times, and eggs were deposited 7 times, and not oftener than once or twice between two matings. Six of the 169 eggs were killed for cytological study, and of the remaining 163, at least 154 hatched. (The number hatched is underestimated, as in two cases, only those nymphs were counted that survived the first moult.) 96 of these nymphs were reared to the winged stage (46 ♂ & 50 ♀).

Forty-three of the males were photographed, and are shown on Plate **29.** Three of the males died in the cage just after the fifth moult. The ventral surface, including the genital segment of these three males, was dark and pathological, and of no value for the demonstration of the genital spot.

A photograph of the male of this pair of F_1 hybrids is shown on Plate **28**, photo 9.

Record V. (p. 365). *Second Pair of* F_1 *Hybrids.*—184 eggs were deposited from August 1st to September 11th. The pair mated 25 times, and eggs were deposited 10 times, and not oftener than once or twice between two matings.

The female was discovered August 1st sucking the group of 28 eggs she had just deposited. She had sucked the entire contents from seven

of the eggs, and she must have injured others, as only eleven of the group developed.

Of the remaining 173 eggs deposited by this female 119 hatched. For some reason we were able to rear only a small proportion of these to the winged stage. We succeeded in rearing only 57 (31 ♂ & 26 ♀). Thirty of these males were photographed, and are shown on Plate **30**. The male of this pair of F_1 hybrids died September 16th. The female was killed September 21st, ten days after the last deposition of eggs.

See photo 14, Plate **28**, for the male of this pair.

RECORD VI. (p. 366). *Third Pair of* F_1 *Hybrids.*—194 eggs were deposited from July 30th to September 2nd. The pair mated 21 times and eggs were deposited 10 times, and not oftener than once or twice between two matings. Seven of the 194 eggs were killed for cytological study. Of the remaining 187 at least 172 hatched—for the number hatched is underestimated, as in two cases we counted only those nymphs that survived the first moult.

110 of these nymphs were reared to the winged stage (54 ♂ & 56 ♀). Forty-eight of the males were photographed and are shown on Plate **31**. Six males died just after the fifth moult. Two of these are preserved as pinned specimens, and four were destroyed because the ventral surface was dark and the bugs were of no value for demonstrating the genital spot. The male of this pair of F_1 hybrids was photographed, and is shown on Plate **28**, photo 10.

RECORD VII. (p. 367). *Fourth Pair of* F_1 *Hybrids.*—170 eggs were deposited from August 8th to September 8th. The pair mated 10 times, and eggs were deposited 8 times, and not oftener than once or twice between two matings. Seven of the 170 eggs were killed for cytological study, and of the remaining 163 at least 130 hatched. This number is an underestimate, for in three cases we counted only those nymphs that survived the first moult. We succeeded in raising to the winged stage only 63 of the 130 nymphs that hatched (28 ♂ & 35 ♀). Twenty-seven of these males were photographed and are shown on Plate **32**, photos 42–48.

We were forced to kill this pair September 11th, as we had as many nymphs in the laboratory as we could properly care for. See photo 12, Plate **28**, for the male of this F_1 hybrid pair.

RECORD VIII. (p. 368). *Fifth Pair of* F_1 *Hybrids.*—110 eggs were deposited from August 8th to September 3rd. The pair mated 10 times and eggs were deposited 6 times, and not oftener than once between two matings. Only 29 of the 110 eggs hatched, and only 16 of these survived to the winged stage (4 ♂ & 12 ♀). The four males were photographed, and are shown on Plate **28**, photos 15 and 16. September 3rd, both male and female of this

pair were killed. We were forced to discard some of the hybrids, and selected this pair because the small percentage of eggs that hatched indicated that they were not functioning normally in spite of the fact that the number of eggs deposited in relation to the number of matings was quite normal. The abnormally large percentage of eggs that failed to hatch may bear some relation to the fact that this female had probably deposited unfertilized eggs before mating, for she was one of two females in a cage in which unfertilized eggs had been deposited.

See photo 11, Plate 28, for the male of this F_1 hybrid pair.

Before giving a summary of the breeding results of the 6th and 7th pairs of F_1 hybrids (Records IX. & X., p. 369) we must give a brief account of some preliminary experiments.

Two F_1 hybrid females and three F_1 hybrid males* were put in Cage 34 immediately after they had reached the winged stage (between July 9th and 12th). By August 6th none of these bugs had mated, and a group of four unfertilized eggs had been deposited by one of these females.

The two females were then transferred to Cage 36, in which there were 4 F_1 hybrid females and 4 F_1 hybrid males that had not yet mated. At 2 P.M. of the same day two pairs were found mating, and were transferred, while mating, to separate cages (Nos. 43 & 44). We believe these two females were the two that were transferred to this cage from Cage 34, though we have no proof of this. One of these pairs (Cage 43) mated $45\frac{1}{2}$ hours, and on August 12th mated again 6 hours. On August 15th the female died without having deposited any eggs. The second pair (Cage 44) is the Fifth pair of F_1 hybrids described above (Record VIII.).

Cage 36 now contained 4 females and 2 males that had never mated. The two males resembled bugs that are found in the fall after the breeding season: the ventral surface had become hard and grey, instead of a fresh green colour, which is typical at the breeding period.

On August 15th we added to this cage the male that had mated August 12th in Cage 43. Ten minutes after this male was put into Cage 36 he mated with one of the four females, and the pair was transferred, while mating, to Cage 46. They mated $15\frac{1}{2}$ hours. There now remained in Cage 36 the three females and the two males with grey venter, none of which had mated. One of these females, however, had a fresh green venter and showed other signs of functional activity.

August 16th, we removed the two males with grey venter from this cage (36) and added the male from Cage 46 that had just mated. At

* Two of these males were killed August 11th and the testes mounted for cytological study. The bugs were preserved and are shown on Plate 28, photo 7. The third male was killed August 13th and preserved as a pinned specimen.

2 P.M. of the same day the female with the green venter mated with this male, and we transferred the pair to Cage 48. Thus the two females of Cages 46 & 48 were fertilized by the same male. The two grey venter males that had never mated were put back into Cage 36, which now contained these two males and two females, none of which had mated. On August 28th these four bugs were killed and preserved. The two males are shown on Plate **28**, photo 8. The male that had mated with the two females (Cages 46 & 48 = Records IX. & X.) was transferred after each mating from one of these cages to the other during the rest of the breeding season. We hoped we could raise enough offspring from each of these two females for a comparative study of the transmission of the genital spot through two different females fertilized by the same male. We were, however, disappointed in this, as we succeeded in raising only seven males from one of the two females —not enough to be of value for comparative study.

The results, briefly, are as follows :—

RECORD IX. (p. 369). *Sixth Pair of* F_1 *Hybrids.*—134 eggs were deposited from August 22nd to September 19th. The pair mated 11 times, and eggs were deposited 10 times, and not oftener than once or twice between two matings. Only 33 of these 134 eggs developed to the point of hatching, although a great many more were fertilized, and there was no obvious reason why they did not hatch. Only 13 of these nymphs survived to the winged stage (7 ♂ & 6 ♀). Six of the males were photographed and are shown on Plate **32**, photos 49 & 50. The male of this pair was killed September 19th and the female September 21st. The male was photographed and is shown on Plate **28**, photo 13 (this male fertilized also the female of Record X.).

RECORD X. (p. 369). *Seventh Pair of* F_1 *Hybrids.*—120 eggs were deposited from August 20th to September 8th. The pair mated 8 times, and eggs were deposited 8 times, and in only one instance were they deposited more than twice between two matings.

104 of these 120 eggs hatched, and 68 of the nymphs were reared to the winged stage (34 ♂ & 34 ♀). Thirty-two of these males were photographed and are shown on Plate **33**, photos 51–57. Two males died in the cage just after the 5th moult, and were destroyed because the ventral surface was dark and pathological.

The above summary of the records of the seven F_1 hybrid pairs shows several features that are apparently typical of this generation of hybrids. These records show further, that if the F_1 hybrids can be secured, the F_2 generation can be obtained in large numbers. The F_1 hybrid generation is quite as fertile as the original pairs of either pure *variolarius* or pure *servus*

during the height of the breeding season, and it is interesting to note that in this fertility they resemble the F_1 generation of *servus*, but not of *variolarius*, for in our experience we have only one case on record in which the F_1 generation of pure *variolarius* mated and deposited fertile eggs the same season. If these records (IV. to X.) are compared with Records I. and II. of pure *variolarius*, it will be seen that, although the F_1 hybrids are not quite normal as to the percentage of eggs that develop, they are entirely normal as to the relation between mating and deposition of eggs, for eggs are deposited only once or twice between two matings, and the matings far exceed in number the deposition of eggs.

The records show that towards the end of the breeding season mating became more frequent, in some cases the breeding season being closed by a series of matings of short duration, which continued several days after the last deposition of eggs. This we believe is characteristic of *servus*, and was typical also of the F_1 generation of two other species we received from the South—*E. ictericus* and *E. crassus*.

We realize our experiments have not been sufficiently numerous to warrant definite conclusions as to the breeding habits of the species we have studied, but they furnish reliable data as far as the limited number of experiments admit. The higher death-rate of the F_2 generation, both as to the eggs and nymphs, we believe was due in part to the fact that the weather was unseasonably cold, and a proper degree of temperature and moisture could not always be satisfactorily maintained for all the cages.

In order to repeat these experiments on a larger scale, a much more elaborate equipment should be available. The bugs should be kept in a hot-house where temperature and moisture can be properly regulated, and the lettuce used for food should be cultivated under supervision, to be sure that no insecticides are used in its cultivation. Further, a number of trained assistants is absolutely necessary. The material furnished by a single cross is at some period of the experiments more than two workers can properly care for. We were forced to cut short several important experiments on account of the impossibility of continuing satisfactorily the extra work they involved.

We believe that our success in being able to cross even one pair of *variolarius* and *servus* is due to the fact that the two females used for the experiments, hatched after the close of the breeding season, and were kept through the following winter. This belief is supported by the fact that we did not succeed in repeating the cross-breeding experiments during the summer with bugs of the first generation of that season, though we tried this with 16 female *variolarius* and 14 male *servus*. These experiments were carried on in three cages, the first started June 22nd, the second June 28th, and the third July 2nd. All the female *variolarius* had been raised in our laboratory during the early summer, and were transferred to these cages

immediately after reaching the winged stage. Five of the male *servus* used in these experiments were raised in our laboratory, and like the *variolarius* females, were transferred to the experiment cages immediately after reaching the winged stage. The other 9 males were wild specimens, received from North Carolina. These experiments were continued for nearly two months, and no mating occurred at any time. The experiments were not closed until many unfertilized eggs had been deposited in all the cages *.

Possibly nymphs captured in the field, and raised to maturity in the laboratory may be more easily bred from; but in our experience we have never been able to collect the wild nymphs early enough in the season to succeed in breeding them with each other, or with an alien species.

The reciprocal cross with the first generation (♀ *servus* & ♂ *variolarius*) also proved unsuccessful; these experiments, as in all other cases, being continued until unfertilized eggs had been deposited a number of times in each cage.

We believe our lack of success in these cross-breeding experiments was not wholly due to the fact that the males and females were of different species, for we were almost as unsuccessful in getting a second generation of pure *variolarius*, though we had much better success in raising the second generation from *servus*. The first generation of this species mated from 10 to 18 days after they reached the winged stage, and were very fertile.

Fortunately for the success of our cross-breeding experiments, the F_1 hybrids resembled *servus* and not *variolarius*, in that most of them mated readily in captivity, from 10 to 20 days after the last moult, and like the first generation of *servus* proved to be very fertile.

The following experiments show it is much more difficult to get a second generation from *variolarius* the same season, although the first generation, if kept through the winter, will normally mate and deposit eggs early in the spring.

In 1911 we experimented with a few pairs of young *variolarius*, all reared from the same batch of eggs. About twenty days after they had reached the winged stage, a few males and females were placed in the same cage, from August 6th to August 27th. During this period they did not mate once, though the females deposited unfertilized eggs, and dissection showed the males to be apparently sexually mature. Two females and four males from this same batch of eggs were carried through the following winter, and in

* As a rule unfertilized eggs are deposited quite differently from those that have been fertilized. The latter are deposited in flat, symmetrical groups containing sometimes more than 30 eggs, and all adhering together. Unfertilized eggs, on the contrary, are dropped here and there on leaves, grasses or berries, sometimes only one or two eggs at a time, or more frequently in groups of three, four, or five. We never destroyed the unfertilized eggs until ten days after their deposition, although fertilized eggs always show the initial stages of development on the 3rd or 4th day.

the spring they mated and deposited eggs quite normally; 330 eggs being deposited by the two females before July 9th, when they were killed. It was from these eggs that we raised the *variolarius* specimens used for the above described unsuccessful cross-breeding experiments with *servus*. We also tried to breed from several of this first generation of *variolarius* to use as a control for our cross-breeding experiments, and to test the above described experiment of 1911 with the first generation of that season. We had three cages of these experiments in 1912, including in all 18 females and 13 males. The first cage was started July 15th, and these experiments were not closed until August 29th. During this period only one pair* of these 31 bugs mated (August 16th) though many unfertilized eggs were deposited in the three cages. The fact that in all these experiments unfertilized eggs were deposited, proves that the young females function the same season, but our experiments indicate that the young males rarely function until the next spring. The following experiments bearing on this point may be added to those already given. As stated above, the young pairs of *variolarius* that were caged in 1911 did not mate, although the females deposited unfertilized eggs. Thinking this might be due to the fact that these bugs were all from the same batch of eggs, we caged one of these F_1 males with a wild female that had just mated with a wild male. They did not mate, however, although the female continued to deposit eggs at normal intervals until August 22nd, and was not killed until September 26th.

In the season of 1912 we were anxious to test this experiment by caging wild males, after they had mated in the laboratory, with young females that were depositing unfertilized eggs, but we did not succeed in capturing any *variolarius* males that season, though we searched ourselves, and had assistants searching also.

That the young *variolarius* males rarely function the same season in the laboratory was again indicated by the following experiment. Five young *variolarius* males had been caged for five weeks with five F_1 hybrid females, and had not mated once, although the females had deposited 88 unfertilized eggs. Thinking that perhaps these males might be sexually immature, they were replaced by the one young *variolarius* male that had mated in the laboratory that season. Eleven days later this male mated with one of the F_1 hybrid females (see Record XI. and p. 345).

These facts would seem to indicate that the young male *variolarius* are not as a rule sexually mature the same season they are hatched, but the evidence on this point is entirely inadequate as proof. *Variolarius* females that were depositing unfertilized eggs also failed to mate with the F_1 *servus* males, and these males were undoubtedly sexually mature, for they breed readily

* This pair was transferred to a separate cage while mating, and used for experiments described below. The male of this pair is shown on Plate 34, photo 58.

with their own species. This may indicate that possibly the factor of selection may be in part responsible for some of the failures of our breeding experiments.

We raised only 10 ♂ and 22 ♀ from the one pair of young *variolarius* that mated in the laboratory in 1912. We undoubtedly would have had more, but the female was fertilized only once, as we transferred this male to the F_1 hybrid females, as described above. This *variolarius* female deposited 58 eggs from August 17th to September 7th, and 36 of these hatched, 32 being reared to the winged stage (10 ♂ & 22 ♀). The F_1 hybrid female that was fertilized by this same male deposited 119 eggs and 36 hatched.

The males from these two females were photographed and are shown on Plate **34**. Photos 59 to 61 show the males from the pure *variolarious* pair, and photos 61 to 66 show the males from the F_1 hybrid female and the pure *variolarius* male.

These photographs demonstrate that the spot is inherited through the pure *variolarius* female (photos 59 to 61) more intensely than it is through the F_1 hybrid female (photos 62 to 66), and a comparison of photos 62 to 66 with those when both parents are F_1 hybrids, Plates **29–33**, demonstrates that the spot is transmitted through a pure male *variolarius* much more strongly than through an F_1 hybrid male. All such facts bearing on the inheritance of the genital spot are important in testing modern chromosome theories of sex-determination in the light of the transmission of this exclusively male character.

Discussion.

Any analysis of the results of cross-breeding experiments involves a discussion of their bearing on fundamental problems of heredity, and we should examine the facts demonstrated by our recent experiments in the light of the popular theories which claim to offer a partial solution of some of the important problems of heredity. The hypothesis of first interest to the cytologist is the one that claims to offer an explanation of the transmission of characters by the assumption that the factors essential to their transmission are carried and distributed by definite chromosomes, but a discussion of our results from this point of view is reserved for a paper in which the cytological phenomena can be fully demonstrated by photographs. A brief statement of the facts and their bearing on recent chromosome theories was given in the preliminary report of our work ('13).

In the present paper we shall merely restate the facts and conclusions in order to present the evidence in detail, as it is demonstrated in the photographs of Plates **28–34**.

First. The results demonstrate that an exclusively male character (the genital spot) can be inherited without the aid of the Y chromosome. This is

proved by the fact that it is transmitted through the female, and the female does not have the Y chromosome, as this chromosome is an exclusively male character. Photographs 7–57 show the males of the F_1 and the F_2 generations. All these males are the hybrid descendants of one pure *variolarius* female, that was fertilized by *servus*—the species that has no genital spot; and these hybrids show beyond question that the spot can be transmitted through the female, some of the F_2 males having as pronounced a spot on the genital segment as that of the *variolarius* males: *e. g.*, one or more of the specimens of photos 15, 23, 26, 28, 32, 34, 35, 36, 40, 41, 46, 48, 55.

Second. The results demonstrate that the genital spot can be inherited without the aid of the X chromosome. This is proved by the fact that it is transmitted through the male, and the male-producing spermatozoon does not have an X chromosome. Photos 62 to 66 show the males from an F_1 hybrid ♀ × a pure *variolarius* ♂, and a comparison of these photographs with those of the F_2 hybrid generation (photos 15 to 57) shows that the genital spot is inherited much more strongly from the pure *variolarius* male than through the F_1 hybrid males; this fact demonstrating that the male *variolarius*, as well as the female *variolarius*, can directly transmit the spot to the males. As, according to the hypothesis, these can be inherited directly from the male, only through the male-producing spermatozoon, which has no X chromosome: it follows that the spot can be inherited without the aid of the X chromosome. This back cross further demonstrates, not only the direct inheritance of the spot from the male, but also the inheritance of the *servus* character, absence of spot. This was transmitted to the F_1 ♀ by the pure *variolarius* ♀ of the first cross, and therefore *ex hypothesi* it must have come from the female-producing spermatozoon of *servus*. This back cross therefore demonstrates that an exclusively male character—the genital spot—can be transmitted by the male-producing spermatozoon, and an exclusively male character—the absence of spot—can be transmitted by the female-producing spermatozoon, and that therefore these so-called sex-determining spermatozoa do not differ functionally in their transmission of an exclusively male character. In making these deductions, it is, of course, necessary to accept, for the sake of the argument, the assumption of male- and female-producing spermatozoa, an assumption which, we believe, is far from being proved.

Third. The results show that if we assume that the factors necessary for the production of the genital spot are located in any of the ordinary chromosomes, they must be in at least both members of a pair of ordinary chromosomes, for the spot is directly transmitted through both the male and the female.

Fourth. The results show that if we assume that the factors necessary for the production of the genital spot are carried by both members of a pair of chromosomes, we must assume that the female carries an inhibitor for the

spot, as the spot is never present in any of the females, neither in the pure *variolarius* nor in the hybrids, although the fact that it is transmitted by the female *variolarius* proves that the spot factors are present in the female, though not expressed.

Fifth. The results show that, although it is necessary to assume an inhibitor only in the females of pure *variolarius*, *in the hybrids it becomes necessary to assume an inhibitor in the males also.* The F_1 hybrid males show the spot either very incompletely, or not at all, although they can transmit the spot to the next generation, and therefore they must carry the factors necessary for its transmission, in spite of the fact that the appearance of the spot in the F_1 generation is partly or wholly inhibited. The two F_1 hybrid males of photo 7 have no spot*, the upper F_1 male of photo 8 has merely an indication of a spot and in the lower bug it is not much stronger. The F_1 males of photos 9 to 13 have a very insignificant spot, and the F_1 male of photo 14 has merely a trace of a spot, although the offspring of these males frequently have a spot quite as pronounced as that of pure *variolarius*. Compare these F_1 males with one or more of the F_2 males of photos 15, 23, 26, 28, 32, 34, 35, 36, 40, 41, 46, 48, and 55.

Sixth. The facts show that if we attempt to place this inhibitor in definite chromosomes, we meet as serious difficulties as those involved in assuming that the factors essential for the production of the genital spot are carried by special chromosomes. In our preliminary report of these experiments (13), we discussed in full the evident results of placing this inhibitor in various chromosomes : in the X chromosomes, in one of the ordinary chromosomes, or in a pair of chromosomes, and we found that none of these assumptions would accord with the facts. The facts force us to regard these inhibitors as hypothetical forces which cannot logically be confined to the chromosomes, and are located we know not where—these hypothetical inhibitors practically doing work that has been assigned to definite chromosomes. As stated in the above-mentioned preliminary report, "the facts force us to consign to these hypothetical inhibitors, not only the responsibility of suppressing the spot factors in all the females, but also of determining just how many spot factors shall find expression in the males of the F_1 and F_2 generations, and thus they practically relieve the chromosomes of the burden of unit distribution."

It would seem then that the facts are out of harmony with the theories that offer an explanation of the transmission of characters on the assumption that the factors essential to their transmission are carried and distributed by definite chromosomes.

* The two dark specks on the genital segment of the upper bug, close to the base of the segment, must not be confused with the genital spot. In the lower bug a slight indication of a spot can be seen with a lens, but it will probably not appear in the print.

If we examine the results of our experiments in the light of Mendel's law of heredity, we find that the genital spot does not behave as a Mendelian unit. Professor Punnett (1911) defines a unit-character as follows : "Unit-characters are represented by definite factors in the gamete which, in the process of heredity, behave as indivisible entities, and are distributed according to a definite scheme. The factor for this or that unit-character is either present in the gamete, or it is not present. It must be there in its entirety, or be completely absent." (Page 42.)

Whatever determines the genital spot in these hybrids, it cannot be an indivisible unit-factor, which is "present in its entirety" or is "completely absent," for the genital spot is not present as a whole, or completely absent. If we speak of it in terms of Mendelism, we must say that it is the result of a number of unit-factors, for in the hybrid males of the F_1 and F_2 generations in which a spot can be identified, it is present in every degree of intensity, from a mere indication of a spot, to that of the F_2 generation which is quite as conspicuous as the spot of a pure *variolarius*.

Neither the spot nor its absence is dominant in the F_1 hybrids. There is certainly an absence of dominance in this F_1 generation. Of the eleven F_1 male hybrids, 2 have no spot (photo 7) : 4 have a spot so faint that it is barely visible (photos 8 and 14 and one pinned specimen) ; and 5 have a spot about one third as pronounced as that of a pure *variolarius* (photos 9, 10, 11, 12, and 13).

It is evident also that the spot of these F_1 hybrids is not a true blend, for only one parent is represented by the two specimens that have no spot, and there is quite as much variation in the size and intensity of the spot of the remaining nine specimens as is found in any nine intermediates of the F_2 generation.

The F_2 generation shows apparently a greater variability than the F_1 generation, for in the former *both* extremes are represented, some of the males having a spot as pronounced as that of pure *variolarius*, while some have no spot whatever, and the remainder have the spot in varying degrees of size and intensity. These facts may be of value as offering a test such as Castle (1911) has suggested, by which it may be possible to decide whether the results can be classed with the Mendelian type of inheritance, or with that described as a "non-Mendelian, non-segregating type of inheritance." Castle says : "There is one means by which we can determine with certainty whether, in a particular case of seemingly blending inheritance, segregation does or does not occur, namely by comparing the variability of the F_1 and F_2 generations. If segregation does not occur, F_2 should be no more variable than F_1, whereas if segregation does occur, F_2 should be more variable." (Page 137.)

Although the F_2 generation of our *Euschistus* hybrids shows more variability than the F_1 generation, the value of this as proof is weakened, if not

cancelled, by the fact that the two generations are not equally represented, and cannot therefore be justly compared. We have 190 males of the F_2 generation in which the exact condition of the spot can be determined, and only 11 males of the F_1 generation; and therefore it would not be reasonable to conclude from such inadequate data, that the F_1 generation of these hybrids is less variable than the F_2 generation. We are inclined to believe that if the number of the F_1 hybrid males were equal to that of the F_2 generation, they would show both extremes of the inheritance of the spot, and a variability quite as pronounced as we find in the F_2 males.

Some of the males of the F_2 generation might be assumed to be pure dominants and recessives, for some have the spot as fully developed as that of pure *rariolarius* (one or more of the specimens of photos 15, 23, 26, 28, 32, 34, 36, 40, 41, 46, 48, and 55), while others have no spot whatever (one or more of the specimens of photos 16 to 39, 43, and 51 to 56). The intermediates show the spot in a very variable degree of intensity, but if these latter are assumed to be "visible heterozygous forms" of Mendelian segregation, there should be an equal number of pure dominants and recessives, whereas there are only 19 that have the perfect *variolarius* spot, and 74 in which the spot is absent.

If we would attempt to find a theoretical explanation of the results, we must first devise a formula that will work for pure *variolarius*, and the facts compel two assumptions in the making of such a formula. First, we must assume that the female is homozygous for the spot factors, and second, that she has an inhibitor for the spot and that she does not transmit this inhibitor to her male offspring. The necessity for this last assumption seems obvious, because the spot is *never* inhibited in the male. If we would assume, however, that both sexes can have an inhibitor, an assumption that some facts in the hybrids demand, then we must assume that it requires a double dose to inhibit the spot; and to insure the spot being a constant character, we must assume that in the male the inhibitor is not only heterozygous but sex-linked. But this assumption, which would hold for *variolarius*, would not work for the cross, because the *female hybrids* would in this case be heterozygous instead of homozygous for the inhibitor, and would therefore have the spot. If to obviate this difficulty we assume that *servus* also has an inhibitor, this would inhibit the spot in the F_1 hybrid *females*, but in *none* of the F_1 *hybrid males*, whereas in fact, the spot is completely or partially inhibited in *all* the F_1 hybrid males.

The necessity of the assumption that the female *variolarius* is homozygous for the *spot factors* is quite obvious, for the genital spot could not remain constant if we assume that the female is heterozygous for the spot factors, unless we add the unwarrantable assumptions that the female is heterozygous and the male homozygous for sex, and that the spot factors are linked with the sex-factor.

We seem compelled, therefore, to assume that the female *variolarius* is homozygous for the spot factors; and if we assume that *servus* is without them, then the F_1 hybrids should be heterozygous for these factors. Assuming that they are inhibited in the female, the males should *all be alike*, either in having a *variolarius* spot or in having no spot. The facts, however, are as follows:—Two of the eleven F_1 hybrid males have no spot (photo 7), and the remaining nine are variable intermediates (8 of the 9 are shown in photos 8–14, and the 9th is a pinned specimen, which has a spot so small and so faint that it is scarcely perceptible).

An interesting case of F_1 hybrids approximating a blend is the cross between the pigmented silky hen and the unpigmented brown leghorn. Prof. Punnett theoretically explains these intermediates (partly pigmented) F_1 fowls by the following assumptions:—

1st. Assumes that the ♀ is heterozygous for femaleness (Ff).
2nd. Assumes that the ♂ is without this sex-factor (ff).
3rd. Assumes that the silky is homozygous for the pigment factor (PP).
4th. Assumes that the silky is without an inhibiting factor (ii).
5th. Assumes that the brown leghorn is without the pigment factor (pp).
6th. Assumes that the brown leghorn is homozygous for an inhibiting factor (II).
7th. Assumes the inhibitor is sex-linked (there is a repulsion between I and F).

If we transfer all these assumptions to the *variolarius* × *servus* cross, even to the extent of assuming that the female instead of the male is heterozygous for the sex factor, they fail to account for the fact that these F_1 hybrids are not *all* intermediates.* *Two are like* servus *in having no spot.* Such irregularities in the F_1 generation are out of harmony with the principles of Mendelism, but in some forms similar evidence against Mendelism has been weakened, if not cancelled, by the fact that the F_2 generation shows a regular Mendelian ratio. This is not the case, however, with the F_2 generation of the *Euschistus* cross—of the 190 F. 2 male hybrids (photos 15–57), 19 have the spot quite as distinct as that of pure *variolarius*, 97 are very variable intermediates, and 74 are like *servus* in having no spot.

The classification of the F_2 hybrids into these three groups is based on a study of the photographs,† and the numbers in each group were afterwards

* It is obvious that in the *females* of *variolarius* a special inhibitor must be assumed that is outside the germ plasm—for *theoretically* the spot appears in the female.

† In classifying the photographs of the hybrids we included under the *servus* type not only all those specimens with no spot whatever, but also those with merely a faint indication of a spot, for the latter was not visible in the living specimens, and probably will not show n the reproductions.

compared with those based on a study of the original specimens immediately after the bugs were killed. The two sets of figures agree almost exactly, differing only in the fact that in the original estimate we classed two specimens as *variolarius* and two as *servus* which we now class as intermediates. Such a variation in the classification is unavoidable because the intermediates blend into the two extremes, and it is not always clear into which division a specimen belongs. Possibly the printing of the photographs in the final plates may be too light in some cases, and fail to bring out a faint spot that should be classed as an intermediate and not *servus*, and this would cause some slight variations from the above figures. If we consider separately the ratio from each of the seven pairs of F_1 hybrids, the results are as follows :—

F. 2 males from the seven pairs of F_1 hybrids.

	1st pair. Plate 29, Photos 17–25.	2nd pair. Plate 30, Photos 26–32.	3rd pair. Plate 31, Photos 33–41.	4th pair. Plate 32, Photos 42–48.	5th pair. Plate 28, Photos 15–16.	6th pair. Plate 32, Photos 49–50.	7th pair. Plate 33, Photos 51–57.	Totals.
Spot like *variolarius.*	1	3	8	4	1	0	2	19
Intermediates.	17	12	27	18	2	5	16	97
No spot like *servus.*	25	15	13	5	1	1	14	74

Of these seven pairs of F_1 hybrids only the 5th pair shows a simple Mendelian ratio (1 like *variolarius*, 2 intermediate, and 1 like *servus*), a ratio which evidently would not have been maintained if a large number of offspring had been secured, for no such ratio is shown by the F_2 hybrids from any of the remaining six pairs, all of which have a larger number of offspring. If one is willing to readjust these ratios by filling the gaps with the nymphs that died and those that failed to hatch, it would be possible of course to create any ratio required, but the assumptions cannot be the same for the seven pairs, and this fact would weaken the value of such an adjustment.

We may further search for a Mendelian ratio (half pure and half heterozygous) in the cross between the F_1 hybrid ♀ and the pure *variolarius* ♂. From this cross we raised 18 males (photos 62–66). 12 of these 18 males

have the spot as strong as *variolarius*, 3 have a spot so small and faint that it is scarcely perceptible (the lower two specimens of photo 62, and the lowest specimen of photo 66), and 3 are quite typical intermediates (the 3rd and 5th specimens of photo 64, and the second specimen of photo 66). Thus 12 of these males have the *variolarius* spot, 3 are intermediates, and 3 are almost without a spot. It therefore seems obvious that a Mendelian ratio is not shown in any of the experiments, it does not appear in the F_1 hybrid generation, in the F_2 hybrid generation, nor in this generation from an F_1 hybrid ♀ by pure *variolarius* ♂.

The above-mentioned cross (F_1 hybrid ♀ × pure *variolarius* ♂) is important because it shows that the genital spot is not a sex-linked character. The test of whether a character is linked to a factor that determines sex is usually made by the "reciprocal cross," which in this case would be pure *servus* ♀ × pure *variolarius* ♂. It is assumed that the parent that is heterozygous for sex can transmit a sex-linked character only to the opposite sex, and therefore none of the males from such a cross should inherit the spot. We were unable to attempt this cross, but the above-mentioned experiment (F_1 hybrid ♀ × pure *variolarius* ♂) shows quite as conclusively as a "reciprocal cross" whether the genital spot behaves as a sex-linked character. This cross demonstrates that the genital spot does *not* behave as a sex-linked character, for it shows that the male *variolarius can directly transmit* the spot to his male offspring, for these offspring show the greatly increased strength of its inheritance from the pure male as compared with its inheritance from the F_1 males.

We cannot explain this exclusively male character by simply assuming that the constitution of the eggs inhibits the expression of the spot in the female, for this leaves unexplained the fact that the spot is partly or wholly inhibited in the F_1 *males*.

We have been unable to harmonize our results either with the Mendelian or non-Mendelian (blend) type of inheritance—the great variability of the F_1 hybrids being the most obvious difficulty. The assumption of multiple factors may be satisfactory as an explanation of the variability of the F_2 intermediates; but it does not explain the variability of the F_1 hybrids. On the assumption of multiple factors the F_1 hybrids should be alike—subject only to minor variations (fluctuations). This, however, is not the case—2 have no spot and 9 are variable intermediates.

Castle's assumption of change in potency of a given factor or factors seems more in harmony with the facts, for this offers not only an explanation of the variability of the F_2 intermediates, but admits any degree of variability in the F_1 hybrids—even to the extent of reversing dominance.

We cannot logically explain the facts on the assumption of variation in potency of a single spot factor, for on this assumption the spot of pure *variolarius* should show the same relative amount of variation, which is not the case. But if we assume that *servus* has an inhibitor which also varies in potency, then the F_1 spot, besides being more or less reduced by a single dose of spot factor which varies in potency, can be further reduced or wholly cancelled by the *servus* inhibitor, according to the degree of its potency.

The hypothesis of varying potency of unit factors demands the presence of at least a perceptible variation in the spot of pure *variolarius*, and such a variability does, in fact, occur. This irregularity can be best appreciated by comparing the male offspring from the same parents.

Castle (1912) says: "In my experience *every* unit character is subject to quantitative variation, that is, its expression in the body varies." The fundamental explanation of his striking results in selection is the assumption that these variations have a germinal basis and are inherited.

It seems to us that our results are more in harmony with Castle's assumption of the varying potency of unit factors; but if they do in fact admit of a pure Mendelian interpretation, this must be left to the specialist in genetics.

APPENDIX I.

Since this paper was finished, striking corroborative support has been given to the results of our experiments.

In expressing to Professor Poulton our desire to find an experienced Entomologist who would look over the parent species of our hybrids for some distinguishing character (other than the genital spot) that might give additional evidence in support of our experiments, Professor Poulton kindly suggested Dr. Harry Eltringham, of New College, Oxford. We feel very grateful to Professor Poulton for his interest and courtesy in this matter, and we are deeply indebted to Dr. Eltringham for his very valuable discovery of the marked difference in the length of the intromittent organ of *E. variolarius* and *E. servus*. As a result of his observation, we have been able to follow out the inheritance of this second exclusively male character in the hybrids from this cross, as well as from the cross between *E. variolarius* and *E. ictericus*.

APPENDIX II.

Records of Eleven Pairs of Bugs that were Isolated through their Breeding Period.

As details of breeding experiments can be of value or interest only to those who may care to repeat such experiments with the same or allied species, we have not published the following details in the text, but have added them here in a convenient form for reference.

The following records are extracts from our notes. We have selected only the main points essential for comparison, omitting such details as the dates of hatching, the dates of the five moults, and the number of nymphs that survived each moult, &c., &c. The length of time given for each mating is the minimum, as it is estimated from the time the pair was found mating until the last record before they were found apart. The bugs were closely watched during the day, and observations made two or three times during the night. The number of eggs that hatched is also the minimum, for in some cases we counted only those nymphs that survived the first moult. Before the first moult these small bugs generally keep closely segregated in a compact mass, and it is impossible to count them accurately when a large number is hatched.

Record I. Cage 2.—1911.

One Pair of *E. variolarius*.

(Collected April 16th, at White Plains, New York, by J. R. de la torre Bueno.)

April				
20th.	6.30 A.M.	mating: continued to mate		9½ hours.
28th.	5.00 P.M.	ditto	ditto	19 hours.
May				
2nd.	1.30 P.M.	ditto	ditto	17½ hours.
7th.	6.00 A.M.	ditto	ditto	9 hours.
10th.	6.00 A.M.	ditto	ditto	15 hours.
22nd.	4 eggs, all hatched: 3 reared to winged stage—(2 ♂ & 1 ♀).			
June				
9th.	29 eggs, 20 hatched. (Found the ♂ sucking these eggs: had sucked the entire contents from two.) 16 reared to winged stage—(7 ♂ & 9 ♀).			
26th.	5.30 A.M. mating: continued to mate 3½ hours.			
July				
1st.	28 eggs, all hatched: 15 reared to winged stage—(9 ♂ & 6 ♀).			
7th.	28 eggs, all hatched. Killed all after 3rd moult to preserve as nymphs.			
13th.	5.30 A.M. mating: continued to mate 6½ hours.			
14th.	5.30 A.M.	ditto	ditto	4¼ hours.

JULY

20th. 5.00 A.M. 28 eggs, all hatched. Killed all after 1st moult to preserve as nymphs.
20th. 5.00 A.M. mating: continued to mate 3 hours.
23rd. 5.30 A.M. ditto ditto $5\frac{1}{2}$ hours.
25th. 12 eggs, all hatched. Did not keep these nymphs beyond the 2nd moult.

AUGUST

5th. 42 eggs, in 3 groups. These eggs not kept.
6th. 5.00 A.M. mating: continued to mate 4 hours.
10th. 11 eggs. These eggs not kept.
19th. 5.30 A.M. mating: continued to mate 27 hours.
23rd 5.30 A.M. ditto ditto $6\frac{1}{2}$ hours.
25th. 28 eggs. These eggs not kept.
31st. The female died. Killed the male and preserved the pair in alcohol.

RECORD II. CAGE 10.—1911.

One Pair of *E. variolarius*.

(Collected April 16th, at White Plains, New York, by J. R. de la torre Bueno.)

APRIL

18th. 7.00 A.M. mating: continued to mate 6 hours.
22nd. 7.30 A.M. ditto ditto $8\frac{1}{2}$ hours.
25th. 1.00 P.M. ditto ditto $5\frac{1}{2}$ hours.
28th. 6.30 A.M. ditto ditto $4\frac{3}{4}$ hours.

MAY

1st. 6.30 A.M. ditto ditto $6\frac{3}{4}$ hours.
10th. 6.00 A.M. ditto ditto $27\frac{1}{2}$ hours.
23rd. 6.00 A.M. ditto ditto $33\frac{1}{2}$ hours.

JUNE

6th. 6.00 A.M. ditto ditto 14 hours.
17th. 5.30 A.M. ditto ditto 14 hours.

JULY

2nd. 28 eggs (watched the ♀ depositing some of these eggs): 27 hatched. Nymphs not kept after 3rd moult.
3rd. 5.30 A.M. mating: continued to mate 36 hours.
5th. 14 eggs, 12 hatched. Killed after 2nd moult to preserve as nymphs.
7th. 13 eggs, all hatched. Nymphs not kept after 2nd moult.
10th. 8 eggs, all hatched. Nymphs not kept after 1st moult.
12th. 5.30 A.M. mating: continued to mate 29 hours.
16th. 3.30 P.M. ditto ditto $19\frac{1}{2}$ hours.
20th. 10 eggs. These eggs not kept.
26th. 5 eggs. ditto.
26th. Killed both the ♂ & ♀ and preserved. We were forced to kill this pair as at this period we had as much living material in our laboratory as we could properly care for.

Record III. Cage 2.—1912.

E. variolarius ♀ × *E. servus* ♂.

May

3rd. 3.00 P.M. mating: continued to mate 7 hours.
23rd. 1 egg, unfertilized (did not show the initial stages of development).
27th. 7 eggs, ditto ditto
28th. 6 eggs: one developed and hatched.
29th. 5.00 A.M. mating: continued to mate 15 minutes.
29th. 1.15 P.M. ditto ditto 18 hours.

June

2nd. 17 eggs: 3 apparently unfertilized, 14 hatched.
8th. 5 eggs: 3 apparently unfertilized, 2 hatched.
11th. 18 eggs, in 3 groups: 12 apparently unfertilized, 6 hatched.
11th. 3.50 P.M. mating: continued to mate 51 hours.
14th. 13 eggs, in 2 groups: 4 apparently unfertilized, 9 fertilized, 8 of which hatched.
18th. 8 eggs: 7 apparently unfertilized; 1 fertilized, but did not hatch. (Watched the female depositing some of these eggs.)
21st. 10 eggs: 9 apparently unfertilized; 1 fertilized, but did not hatch. (Watched the female depositing some of these eggs.)
25th. 10 eggs, in 2 groups: 8 apparently unfertilized, 2 hatched. (Watched the female depositing some of these eggs.)
30th. 16 eggs, in 3 separate groups: 15 apparently unfertilized, 1 hatched.

July

9th. 9 eggs, in 3 groups: all apparently unfertilized.
16th. The female died.

Total number of eggs deposited	120
„ „ apparently not fertilized	83
„ „ fertilized but failed to hatch	5
„ „ hatched	32

Record IV. Cage 38.—1912.

First Pair of F_1 Hybrids.

July

19th. 6.00 P.M. mating: continued to mate 15 hours.
28th. 5.00 A.M. ditto ditto 28 hours.

August

2nd. 31 eggs *, 30 hatched: 14 reared to the winged stage—(9 ♂ & 5 ♀).
3rd. 5.00 A.M. mating: continued to mate 16 hours.
4th. 17 eggs, all hatched: 13 reared to the winged stage—(5 ♂ & 8 ♀).
7th. 5.30 P.M. mating: continued to mate 15½ hours
9th. 22 eggs, all hatched: 13 reared to the winged stage—(6 ♂ & 7 ♀).
12th. 28 eggs: 26 survived 1st moult: 18 reared to the winged stage—(9 ♂ & 9 ♀).

* Unless stated to the contrary, the eggs were deposited in one symmetrical group, which is typical of both *variolarius* and *servus*.

August

13th. 5.00 A.M. mating: continued to mate 26 hours.
17th. 9.00 P.M. ditto ditto 14 hours.
19th. 30 eggs (one group of 8 & one group of 22 eggs): killed 6 for cytological study. 14 reared to winged stage—(9 ♂ & 5 ♀).
19th. 6.00 P.M. mating: continued to mate 26 hours.
21st. 7.30 P.M. ditto ditto 2 hours.
22nd. 3.30 P.M. ditto ditto 5 hours.
24th. 5.45 P.M. ditto ditto 5 hours.
25th. 6.30 P.M. ditto ditto 4 hours.
26th. 5.30 P.M. ditto ditto $4\frac{1}{2}$ hours.
27th. 21 eggs (at 10 A.M.): 18 survived 1st moult, 12 reared to winged stage—(3 ♂ & 9 ♀).
27th. 5.30 P.M. mating: continued to mate 3 hours.
28th. 4.00 P.M. ditto ditto $3\frac{1}{2}$ hours.

July

30th. The male died and was preserved in glycerine (tube 34).
31st. 20 eggs (deposited on wire top of cage): 19 hatched, 12 reared to winged stage—(5 ♂ & 7 ♀).

September

3rd. Killed the ♀ and preserved in glycerine. This female would undoubtedly have deposited more fertilized eggs, but at this period we had as many nymphs developing from all the hybrid pairs as we could properly care for, and were forced to be satisfied with the number of offspring already secured from this pair. The male was photographed, and is shown on Plate 28, photo 9.

Record V. Cage 39.—1912.

Second Pair of F_1 Hybrids.

July

19th. 9.00 P.M. mating: continued to mate 13 hours.
30th. 5.00 P.M. ditto ditto $16\frac{1}{2}$ hours.

August

1st. 28 eggs. Discovered the ♀ sucking these eggs; she had taken the entire contents from 7 and probably more were injured, as only 11 hatched. 8 reared to winged stage—(5 ♂ & 3 ♀).
5th. 28 eggs, 17 hatched (6 survived 2nd moult). These were later caged wit nymphs from eggs deposited August 12th.
6th. 6.00 P.M. mating: continued to mate 57 hours.
12th. 11 eggs, 3 hatched. These were later caged with nymphs from eggs deposited August 5th. 8 reared to winged stage—(4 ♂ & 4 ♀).
12th. 7.30 P.M. mating: continued to mate $12\frac{1}{2}$ hours.
13th. 30 eggs, 24 hatched: 13 reared to winged stage—(5 ♂ & 8 ♀).
15th. 3.30 P.M. mating: continued to mate $15\frac{1}{2}$ hours.
16th. 15 eggs, 12 hatched: 6 reared to winged stage—(4 ♂ & 2 ♀).

August.

16th. 6.00 P.M. mating: continued to mate 9½ hours.
19th. 6.00 P.M. ditto ditto 15 hours.
20th. 19 eggs, 15 hatched: 7 reared to winged stage—(6 ♂ & 1 ♀).
22nd. 7.30 P.M. mating: continued to mate 13½ hours.
24th. 23 eggs, 15 hatched: 5 reared to winged stage—(3 ♂ & 2 ♀).
24th. 5.45 P.M. mating: continued to mate 9¾ hours.
25th. 2.00 P.M. ditto ditto 8½ hours.
26th. 5.30 P.M. ditto ditto 4½ hours.
27th. 5.30 P.M. ditto ditto 5 hours.
28th. 7.30 P.M. ditto ditto 6¾ hours.
30th. 8 eggs: 6 hatched (2 survived 2nd moult). These were later caged with nymphs from eggs deposited September 3rd and September 11th.
30th. 4.30 P.M. mating: continued to mate 4½ hours.
31st. 3.45 P.M. ditto ditto 5¼ hours.

September

1st. 6.15 A.M. ditto ditto 2¼ hours.
1st. 9.00 P.M. ditto ditto 2½ hours.
2nd. 4.45 P.M. ditto ditto 7¼ hours.
3rd. 7 eggs (4 survived 1st moult). These were later caged with nymphs from eggs deposited August 30th and September 11th.
3rd. Noon, mating: continued to mate 3½ hours.
3rd. 4.30 P.M. mating: continued to mate 5½ hours.
4th. 3.00 P.M. ditto ditto 9 hours.
5th. 6.15 P.M. ditto ditto 2¼ hours.
8th. 7.30 P.M. ditto ditto 4½ hours.
9th. 5.15 P.M. ditto ditto 1¼ hours.
11th. 15 eggs, 12 hatched (8 survived 2nd moult): added these to nymphs from eggs deposited Aug. 30th & Sept. 3rd. 10 reared to winged stage—(4 ♂ & 6 ♀).
12th. 6.00 P.M. mating: continued to mate 11 hours.
16th. The ♂ died: preserved in glycerine (tube 44). This male was photographed, and is shown on Plate 28, photo 14.
21st. Killed the ♀. Preserved in glycerine (tube 44).

Record VI. Cage 40.—1912.

Third pair of F_1 Hybrids.

July

24th. 5.00 A.M. mating: continued to mate 6½ hours.
30th. 28 eggs, all hatched: 15 reared to the winged stage—(5 ♂ & 10 ♀).
31st. 5.00 A.M. mating: continued to mate 16 hours.

August

1st. 28 eggs: 25 survived 1st moult; 18 reared to winged stage—(11 ♂ & 7 ♀).
3rd. 28 eggs: 20 survived 1st moult; 12 reared to winged stage—(6 ♂ & 6 ♀).
6th. 6.00 P.M. mating: continued to mate 17 hours.
11th. 7.30 P.M. ditto ditto 2 hours.
16th. 5.00 A.M. ditto ditto 2 hours.

AUGUST

16th. 10.00 A.M. 28 eggs, all hatched: 17 reared to winged stage—(10 ♂ & 7 ♀).
16th. 9.00 P.M. mating: continued to mate 6½ hours.
17th. 3.45 P.M. ditto ditto 5¾ hours.
18th. 2.00 P.M. ditto ditto 7½ hours.
19th. 6.00 P.M. ditto ditto 3½ hours.
20th. 14 eggs. Killed 7 for cytological study; the remaining 7 hatched. Added 6 that survived the 2nd moult to nymphs from eggs deposited August 27th. Reared the 6 to winged stage.
20th. 7.30 P.M. mating: continued to mate 3 hours.
21st. 1.30 P.M. ditto ditto 8 hours.
22nd. 3.30 P.M. ditto ditto 8 hours.
24th. 5.45 P.M. ditto ditto 4¾ hours.
25th. 6.30 P.M. ditto ditto 4 hours.
26th. 17 eggs, 16 hatched: 6 reared to winged stage—(4 ♂ & 2 ♀).
26th. 5.30 P.M. mating: continued to mate 4 hours.
27th. 10 eggs, all hatched: 9 reared to winged stage; 15 in this cage including the 6 added from eggs deposited August 20th—(8 ♂ & 7 ♀).
27th. 3.30 P.M. mating: continued to mate 6½ hours.
28th. 7.30 P.M. ditto ditto 5¾ hours.
29th. 5.15 P.M. ditto ditto 4¼ hours.
30th. 13 eggs, 12 hatched: 8 that survived were later caged with nymphs from eggs deposited September 7th.
30th. 4.00 P.M. mating: continued to mate 7 hours.

SEPTEMBER

2nd. 15 eggs, all hatched: 10 reared to winged stage—(6 ♂ & 4 ♀).
2nd. 4.15 P.M. mating: continued to mate 3¾ hours.
3rd. 8.00 P.M. ditto ditto 1 hour.
4th. The male died, and was preserved in glycerine (tube 38). This male is shown on Plate 28, photo 10.
7th. 12 eggs, 11 hatched, and after the 2nd moult 8 nymphs were added from the eggs deposited August 30th. 17 reared to winged stage—(4 ♂ & 13 ♂).
7th. Killed the female and preserved in glycerine (tube 38). We were forced to kill this female, as at this period we had as many nymphs as we could properly care for.

RECORD VII. CAGE 41.—1912.

Fourth Pair of F_1 Hybrids.

JULY

28th. 6.00 P.M. mating: continued to mate 12¼ hours.

AUGUST

8th. 20 eggs, 15 hatched: 8 reared to winged stage—(4 ♂ & 4 ♀).
13th. 5.00 A.M. mating: continued to mate 31 hours.
17th. 25 eggs, 22 hatched: 13 reared to winged stage—(7 ♂ and 6 ♀).
22nd. 18 eggs, 15 hatched: 5 reared to winged stage—(1 ♂ & 4 ♀).
23rd. 3.30 P.M. mating: continued to mate 40 hours.
25th. 6.30 P.M. ditto ditto 17 hours.
27th. 26 eggs, 21 hatched: 9 reared to winged stage—(2 ♂ & 7 ♀).
27th. 5.30 P.M. mating: continued to mate 13½ hours.

AUGUST

28th. 16 eggs, 13 survived 1st moult: These were later caged with nymphs from eggs deposited September 8th.

31st. 27 eggs, 23 survived 1st moult: 12 reared to winged stage—(4 ♂ & 8 ♀).

31st. 5.30 P.M. mating: continued to mate 11½ hours.

SEPTEMBER

5th. 24 eggs, 16 survived 1st moult: 7 reared to winged stage—(4 ♂ & 3 ♀).

5th. 6.15 P.M. mating: continued to mate 49 hours.

8th. 14 eggs (7 killed for cytological study): 5 hatched; added these to nymphs from eggs deposited August 28th. (18 in all.) 9 reared to winged stage—(6 ♂ & 3 ♀).

8th. 2.30 P.M. mating: continued to mate 11½ hours.

9th. 5.15 P.M. ditto : ditto 6 hours.

10th. 7.00 P.M. ditto : ditto 2 hours.

11th. Killed both ♂ and ♀, and preserved in glycerine (tube 42). The male is shown on Plate 28, photo 12. We were forced to kill this pair, as we had as many nymphs in the laboratory as we could properly care for.

RECORD VIII. CAGE 44.—1912.

Fifth Pair of F_1 Hybrids.

AUGUST

6th. 2.00 P.M. mating: continued to mate 39 hours.

8th. 25 eggs, 2 hatched: none reared to winged stage.

9th. 5.00 P.M. mating: continued to mate 4 hours.

11th. 5.00 A.M. ditto ditto 1 hour.

14th. 13 eggs (1 group of 10 and 1 group of 3): 9 hatched, 7 survived 3rd moult. These were caged later with nymphs from eggs deposited August 20th.

15th. 6.00 P.M. mating: continued to mate 14 hours.

19th. 5.00 A.M. ditto ditto 4½ hours.

20th. 13 eggs: 8 survived 1st moult, 4 survived 2nd moult. Added to nymphs from eggs deposited August 14th. 8 reared to winged stage—(1 ♂ & 7 ♀).

23rd. 3.30 P.M. mating: continued to mate 16 hours.

27th. 30 eggs: one hatched. Did not rear.

27th. 7.30 P.M. mating: continued to mate 14½ hours.

28th. 7.30 P.M. ditto ditto 9¾ hours.

29th. 15 eggs: 11 survived 1st moult, 4 survived 3rd moult. These were later caged with nymphs from eggs deposited September 3rd.

SEPTEMBER

1st. 9.00 P.M. mating: continued to mate 7 hours.

2nd. 4.45 P.M. ditto ditto 7¼ hours.

3rd. 14 eggs, 8 hatched: 5 survived 2nd moult, added these to nymphs from eggs deposited August 29th; 8 reared to winged stage—(3 ♂ & 5 ♀).

3rd. Killed both the ♂ & ♀, and preserved them in glycerine (tube 37). The male is shown on Plate 28, photo 11.

We killed this pair because the small percentage of eggs that had hatched indicated that these bugs were not functioning normally.

Record IX. Cage 46.—1912.

Sixth Pair of F_1 Hybrids.

(This ♀ and the ♀ of Cage 48 were fertilized by the same ♂.)

August

15th. 3.30 P.M. mating: continued to mate 15½ hours.

22nd. 21 eggs, 6 hatched (only 2 survived the 1st moult): later added these to nymphs from eggs deposited August 27th.

27th. 9 eggs, all hatched: added these to nymphs from eggs deposited August 22nd. 5 reared to winged stage—(2 ♂ & 3 ♀).

27th. 7.30 P.M. mating: continued to mate 3 hours.

29th. 14 eggs, 1 hatched and died after 1st moult.

29th. 5.15 P.M. mating: continued to mate 4¼ hours.

September

3rd. 14 eggs. All fertilized, but none hatched.

3rd. 2.30 P.M. mating: continued to mate 7½ hours.

4th. 12 eggs: 7 fertilized, but none hatched.

4th. 3.00 P.M. mating: continued to mate 6 hours.

5th. 6.15 P.M. ditto ditto 1¼ hours.

8th. 19 eggs, 5 hatched. Later added these to nymphs from eggs deposited September 11th and September 14th.

11th. 11 eggs, 10 hatched, 8 survived first moult. Added these to nymphs from eggs deposited September 8th and September 14th.

11th. 5.45 P.M. mating: continued to mate 5¾ hours.

12th. 6.00 P.M. ditto ditto 4 hours.

13th. 6.00 P.M. ditto ditto 2½ hours.

14th. 14 eggs, nearly all fertilized, 3 hatched. Added these to nymphs from eggs deposited September 8th and September 11th. 8 reared to winged stage—(5 ♂ & 3 ♀).

17th. 12 eggs: 11 fertilized, but none hatched.

17th. 12.45 P.M. mating: continued to mate 7¾ hours.

18th. 8·00 P.M. ditto ditto 5½ hours.

19th. 8 eggs: 4 fertilized, none hatched.

19th. Killed the male and preserved in glycerine (tube 49). This male was photographed, and is shown on Plate 28, photo 13.

21st. Killed the female and preserved in glycerine (tube 49).

Record X. Cage 48.—1912.

Seventh Pair of F_1 Hybrids.

(This ♀ and the ♀ of Cage 46 were fertilized by the same ♂.)

August

16th. 9.00 P.M. mating: continued to mate 8 hours.

19th. 5.00 A.M. ditto ditto 5 hours.

20th. 21 eggs, 20 hatched: 15 reared to winged stage—(6 ♂ & 9 ♀).

22nd. 15 eggs: 13 survived first moult. 10 reared to winged stage—(4 ♂ & 6 ♀).

August

26th. 5.00 A.M., 28 eggs (one group of 16 and one group of 12): 26 hatched, 14 reared to winged stage—(3 ♂ & 11 ♀).

27th. 5.30 A.M. mating: continued to mate $16\frac{1}{2}$ hours.

28th. 14 eggs, 4 hatched. These were caged later with nymphs from eggs deposited August 31st.

31st. 14 eggs, 14 hatched. Added these to nymphs from eggs deposited August 28th. 12 reared to winged stage—(10 ♂ & 2 ♀).

31st. 3.30 P.M. mating: continued to mate $9\frac{3}{4}$ hours.

September

1st. 9.00 P.M. ditto ditto 8 hours.

2nd. 14 eggs, 13 hatched. 9 reared to winged stage—(6 ♂ & 3 ♀).

2nd. 4.45 P.M. mating: continued to mate $3\frac{1}{4}$ hours.

5th. 10 eggs, all hatched. These were caged later with nymphs from eggs deposited September 8th.

7th. 4.30 P.M. mating: continued to mate 3 hours.

8th. 4 eggs, all hatched. Added these to nymphs from eggs deposited September 5th. 8 reared to winged stage—(5 ♂ & 3 ♀).

8th. 7.30 P.M. mating: continued to mate 2 hours.

17th. Killed the female, as she had not mated nor deposited eggs for 9 days: preserved in glycerine (tube 46). The male is shown on Plate 28, photo 13.

Record XI. Cage 50.—1912.

One Pair F_1 Hybrid ♀ × Pure *variolarius* ♂.

August

22nd. 7.30 P.M. mating: continued to mate 13 hours.

25th. 9 eggs: 7 developed, but failed to hatch.

27th. 11 eggs: all developed, 2 hatched. After second moult, these were caged with nymphs from eggs deposited September 2nd and September 3rd.

28th. 15 eggs: 13 developed, but none hatched.

30th. 14 eggs, 10 hatched. 9 reared to winged stage—(7 ♂ & 2 ♀).

September

2nd. 6 eggs, 5 developed, but only 1 hatched. After first moult, this was caged with nymphs from eggs deposited August 27th and September 3rd.

3rd. 8 eggs, all developed, 3 hatched. Added these, after first moult, to nymphs from eggs deposited August 27th and September 2nd. 4 reared to winged stage—(3 ♂ & 1 ♀).

4th. 13 eggs, 5 hatched. These were caged later with nymphs from eggs deposited September 16th and September 18th.

8th. 11 eggs, all hatched: 7 reared to winged stage—(3 ♂ & 4 ♀).

11th. 14 eggs, 13 developed, but none hatched.

13th. 4 eggs, all developed, but none hatched.

16th. 10 eggs, 9 developed, 2 hatched. Added these later to nymphs from eggs deposited September 4th and 18th.

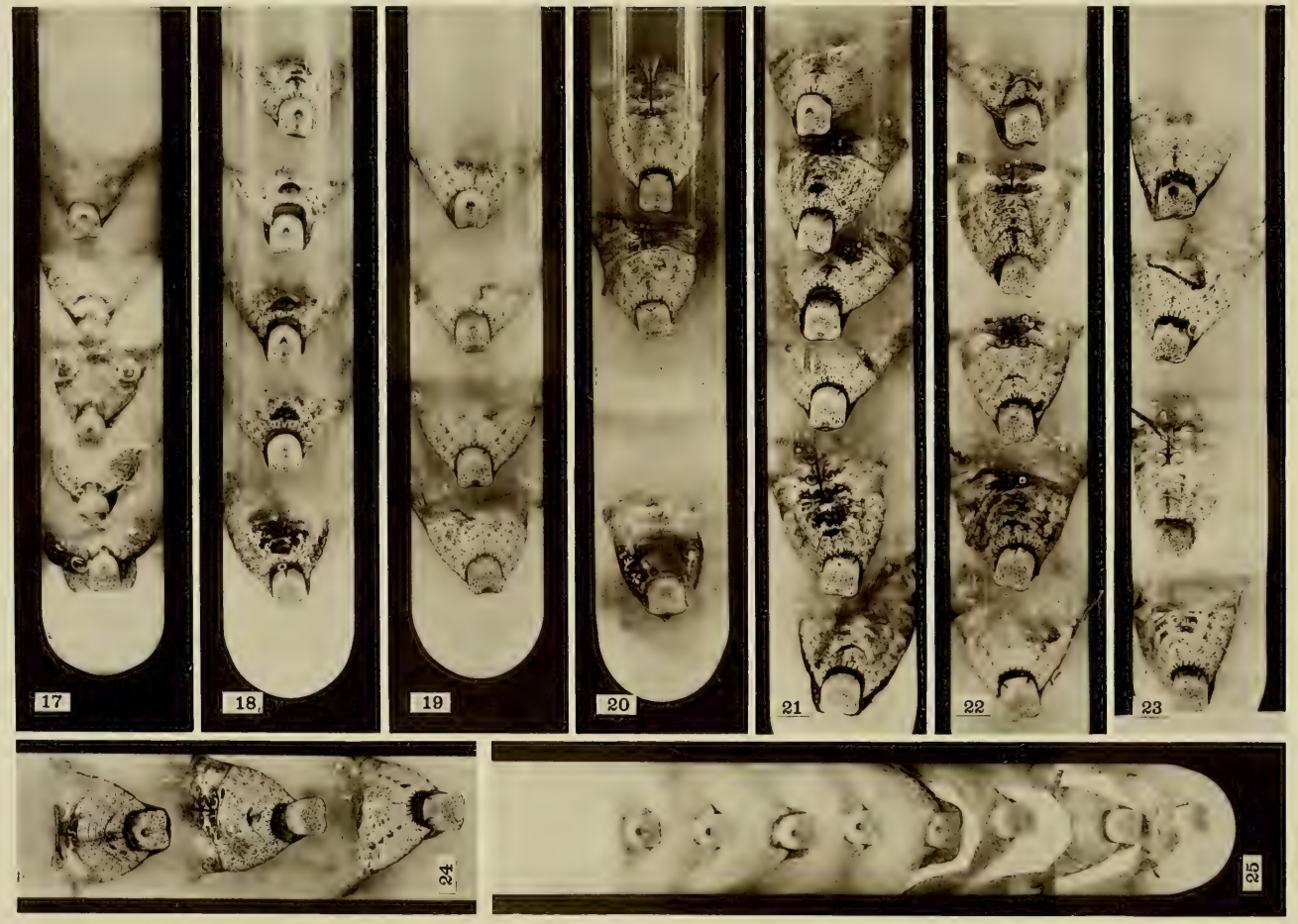
18th. 4 eggs, 2 hatched. Added these, after second moult, to nymphs from eggs deposited September 4th and September 16th. 6 reared to winged stage—(5 ♂ & 1 ♀).

Both parents killed and preserved in glycerine (tube 47). The male was photographed, and is shown on Plate 34, photo 58.



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EUSCHISTUS VARIOLARIUS, E. SERVUS & HYBRIDS.



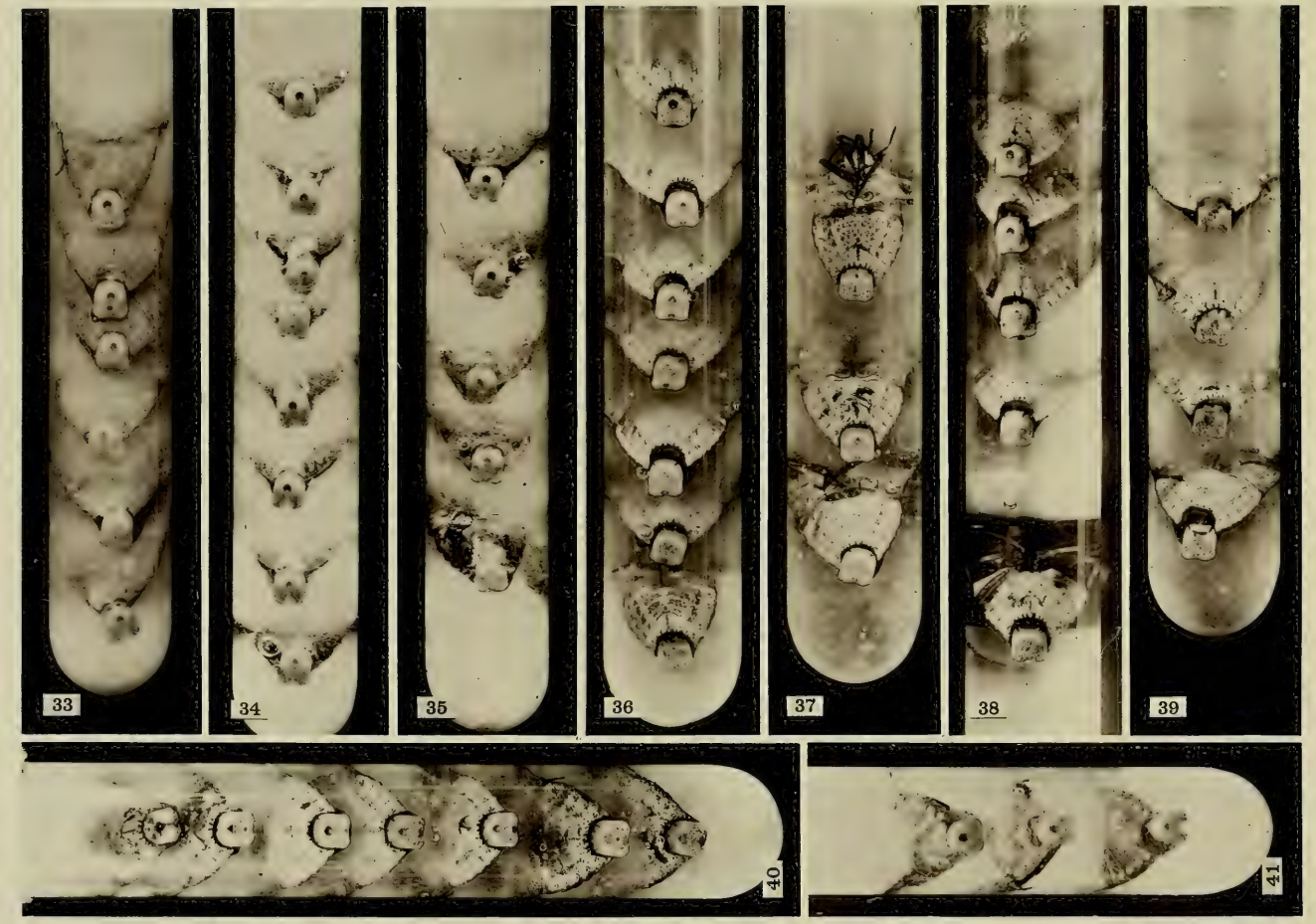
Anglo Engraving Co

F2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



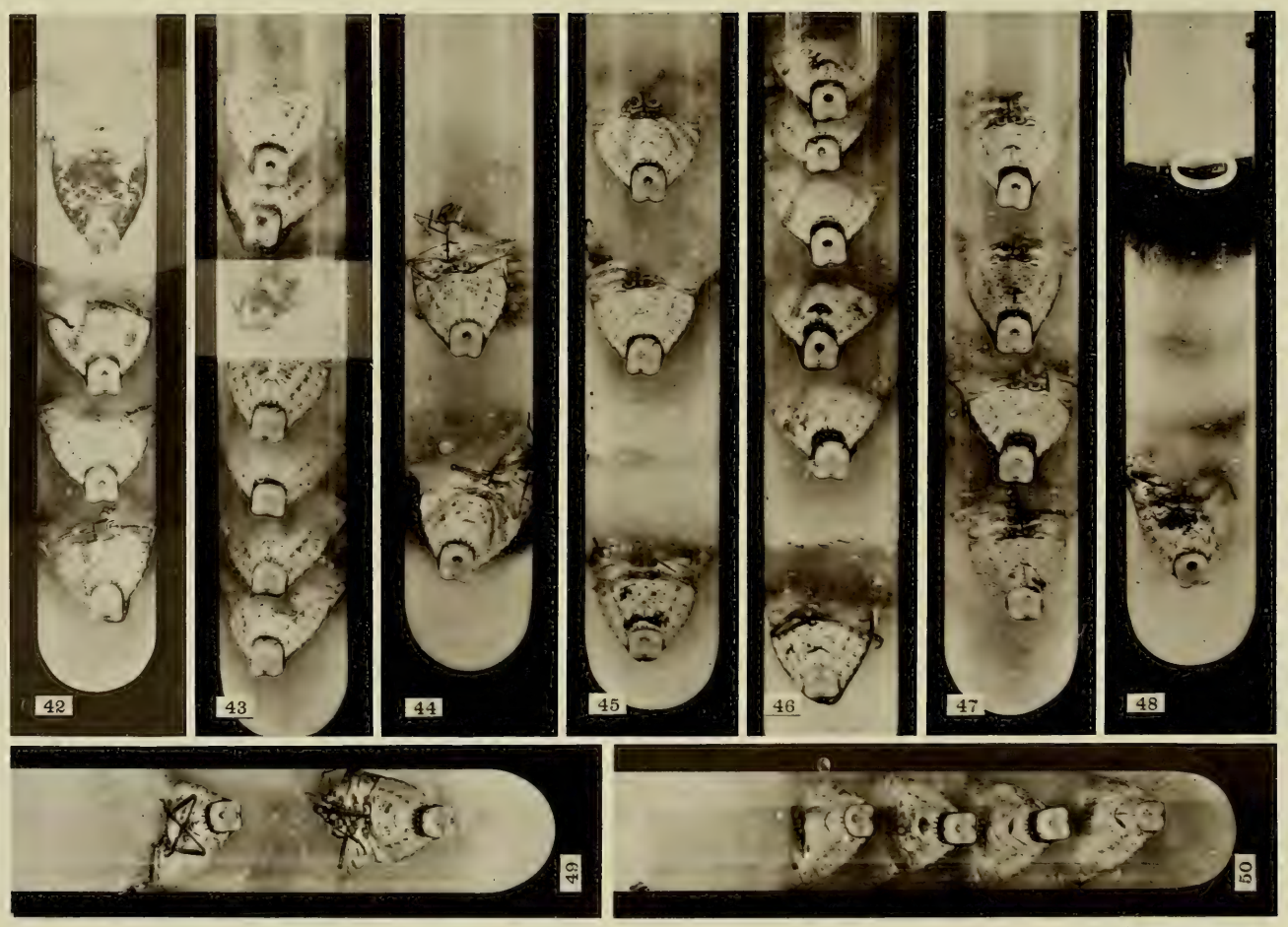
Anglo Engraving Co.

F2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



Anglo Engraving Co.

F2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



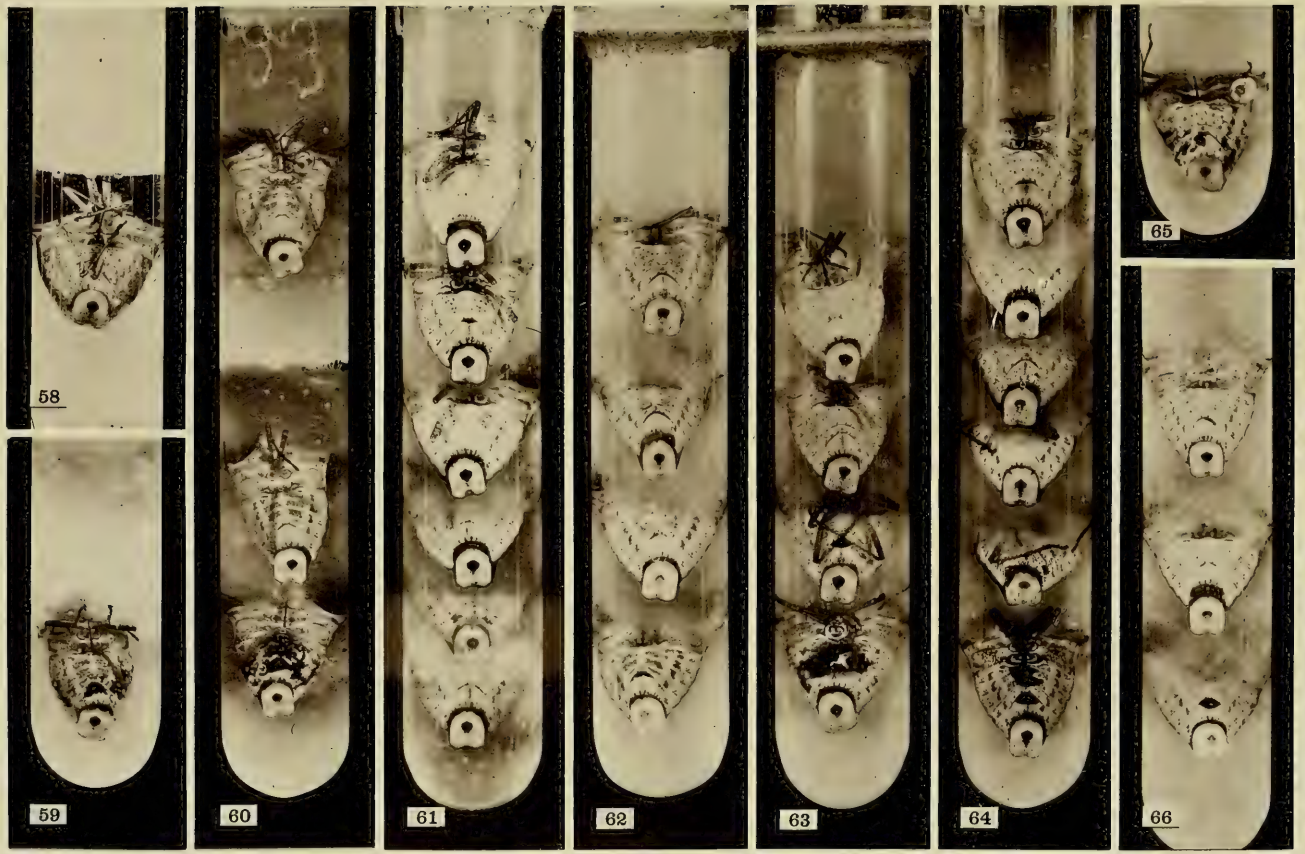
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F2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



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F2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



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E. VARIOLARIUS MALES, & MALES from F1 ♀ X E. VARIOLARIUS ♂

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EXPLANATION OF THE PLATES.

All the photographs are of male specimens. In all cases only the ventral surface of the bugs is shown.

The two bugs of photo 1 are dried specimens. Those of photos 2 to 66 are preserved in glycerine *. The specimens are placed serially in a small test-tube which is filled with pure glycerine and hermetically sealed. The genital segment of each bug has been pulled out and cotton inserted behind the segment to hold it in position to show the entire ventral surface.

The magnification is about $1\frac{1}{2}$ diameters: this varies slightly because the work was done by two photographers, and they did not give exactly the same enlargement. The reproductions are bromide prints made directly from large negatives of the original plates; the individual photographs of which these plates were composed being sunprints from the original negatives.

PLATE 28.

PHOTO 1. Male specimens of *Euschistus variolarius* and *Euschistus servus*. On the left is *E. variolarius*, showing the ventral surface and the clearly defined black spot, always present on the genital segment of the males of this species. On the right is *E. servus*, showing the ventral surface and the genital segment without any trace of the black spot typical of *variolarius*.

PHOTO 2. Seven male specimens of *E. variolarius*, showing the typical black spot on the genital segment. These specimens are from the first generation of 1912. The parent bugs were of the first generation of 1911, which were kept in captivity through the winter of 1911–12.

PHOTO 3. Five male specimens of *E. servus* received from North Carolina in the fall of 1912.

PHOTO 4. The wild *E. servus* male that fertilized the *E. variolarius* female.

PHOTO 5. Three of the five *E. servus* males that were caged all winter with *E. variolarius* females: *see* page 342.

* We are indebted to Prof. Ralph Tower, of the Museum of Natural History of New York, for suggesting the use of glycerine as a preservative.

PHOTO 6. One of the two male *E. variolarius* from the same deposition of eggs from which we raised the three females for crossing with *E. servus* : *see* page 342.

PHOTO 7. Two male specimens of the F_1 hybrid generation. These bugs were killed August 11th, 1912, and their testes dissected out and mounted for cytological study.

PHOTO 8. Two male specimens of the F_1 hybrid generation. Killed August 28th, 1912.

PHOTO 9. The male of the first pair of F_1 hybrids. The F_2 males from this pair of hybrids are shown on Plate **29**, photos 17–25. *See* Record IV. and page 346.

PHOTO 10. The male of the third pair of F_1 hybrids. The F_2 males from this pair of hybrids are shown on Plate **31**, photos 33–41. *See* Record VI. and page 347.

PHOTO 11. The male of the fifth pair of F_1 hybrids. The F_2 males from this pair of hybrids are shown on Plate **28**, photos 15 and 16. *See* Record VIII. and page 347.

PHOTO 12. The male of the fourth pair of F_1 hybrids. The F_2 males from this pair of hybrids are shown on Plate **32**, photos 42–48. *See* Record VII. and page 347.

PHOTO 13. The male of the sixth and seventh pairs of F_1 hybrids. The F_2 males from the sixth pair are shown on Plate **32**, photos 49 & 50, and the F_2 males from the seventh pair are shown on Plate **33**, photos 51–57. *See* Records IX. and X. and page 349.

PHOTO 14. The male of the second pair of F_1 hybrids. The F_2 males from this pair are shown on Plate **30**, photos 26–32. *See* Record V. and page 346.

PHOTOS 15–16. Four F_2 males from the fifth pair of F_1 hybrids. *See* photo 11 for the male of this pair of hybrids, Record VIII. and page 347.

PLATE 29.

PHOTOS 17–25. Forty-three F_2 males from the first pair of F_1 hybrids. *See* photo 9, Plate **28**, for the male of this pair of hybrids, Record IV. and page 346.

PLATE 30.

PHOTOS 26–32. Thirty F_2 males from the second pair of F_1 hybrids. *See* photo 14, Plate **28**, for the male of this pair of F_1 hybrids, Record V. and page 346.

PLATE 31.

PHOTOS 33–41. Forty-eight F_2 males from the third pair of F_1 hybrids. *See* photo 10, Plate **28**, for the male of this pair of hybrids, Record VI. and page 347.

PLATE 32.

PHOTOS 42–48. Twenty-seven F_2 males from the fourth pair of F_1 hybrids. *See* photo 12, Plate **28**, for the male of this pair of hybrids, Record VII. and page 347.

PHOTOS 49–50. Six F_2 males from the sixth pair of F_1 hybrids. *See* photo 13, Plate **28**, for the male of this pair of hybrids, Record IX. and page 349.

PLATE 33.

PHOTOS 51–57. Thirty-two F_2 males from the seventh pair of F_1 hybrids. *See* photo 13, Plate **28**, for the male of this pair of hybrids, Record X. and page 349.

PLATE 34.

PHOTO 58. The pure male *variolarius* that was raised in the laboratory in 1912, and the same season fertilized both a pure female *variolarius* and the F_1 hybrid female of Record XI., and pages 345, 353.

PHOTOS 59–61. Ten males from the above mentioned pair of pure *variolarius*. *See* photo 58 for the male of this pair.

PHOTOS 62–66. Eighteen males from the above mentioned F_1 hybrid female, fertilized by the pure *variolarius* male of photo 58, Record XI. and pages 345, 352–3.

On a Collection of Land and Freshwater Gastropoda from Madagascar, with Descriptions of new Genera and new Species.

By Guy C. Robson, B.A. (Communicated by Prof. G. C. Bourne, F.R.S., Sec.L.S.)

(Plate 35, and 6 Text-figures.)

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[Read 4th June, 1914.]

The collection described here was formed by the Hon. P. A. Methuen and M. Perrier de la Bathie in Madagascar, and was sent by the first named to Prof. G. C. Bourne, F.R.S., by whom they were handed over to the British Museum for examination. The bulk of the material was collected by Messrs. Methuen and de la Bathie personally during their residence in the island, while a part was obtained from a field-collector, M. Herschell Chauvin Messrs. Methuen and de la Bathie have kindly presented the types of new forms here described and the major part of the rest of the collection to the British Museum.

The specimens collected are mainly of conchological interest, and the new genera and new species have been established upon conchological characters; but it is believed that they are sufficiently clearly marked in each case to warrant such a superficial diagnosis. Examples of some of the animals of which the shells have been described here are available, and it is hoped that it will be possible to publish an account of the anatomy. (See Appendix.) Absence of this sort of information must necessarily prevent any positive assertions being made upon the relationships of the molluscan fauna of Madagascar in the light of this collection, conchological resemblances being very inadequate evidence for basing such generalizations upon. Certain of the conclusions, provisional in so far as they depend upon conchological evidence alone, may be however alluded to here.

It has long been known that the land and freshwater Mollusca of Madagascar exhibit closer affinities with those of the Oriental region than with those of continental Africa. The resemblance may not be very marked. The molluscan fauna of this island is peculiar and individual. But where its affinities are obvious they appear to be as indicated above. Moreover, the converse is true—some very distinctive groups of African mollusca are either absent or only sparsely represented in Madagascar (Cooke, 'The Conchologist,' vol. ii.). Specimens obtained by Messrs. Methuen and de la Bathie lend support to this view, though only, as has been admitted above, of a provisional nature. It may be worth while to point out the interesting forms.

The new genus, for which the name *Bathia* has been proposed, is undoubtedly the most interesting feature of the collection. In the absence of

anatomical knowledge we have to point out that the characters of the shell approximate it to the very characteristic genus *Taphrospira*, which is confined to India, Burma, and the Andaman Islands. If the conchological evidence is supported by the anatomical (the animal itself was unfortunately not found), the relationship thus established will be even more satisfactory than the occurrence in Madagascar of the characteristic *Kaliella barrakporensis* and *K. sigurensis* of India, for in the latter instances it is impossible to assert with any certainty that the two species in question were not introduced by human agency. Again, the genus *Kalidos* recently proposed by Gude (Proc. Malac. Soc. vol. ix. p. 269), and now reinforced by another species here described, appears to constitute a further link with the East. The affinities of this genus are doubtful. They may be with the *Xesta*-forms, which have a wide distribution in the Malay Archipelago and farther east as far as the Solomon and Admiralty Islands. But Col. Godwin-Austen informs the author that he suspects its affinities possibly are with the South Indian *Ariophanta*.

Finally, we may direct attention to a fact that does not appear to have been commented on before. It would appear that it is with the South Indian, Singhalese, and possibly Malaysian forms, rather than with the North Indian fauna, that the Malagasy fauna has to be compared.

The following is an analysis of the eighteen genera comprised in the collection of Messrs. Methuen and de la Bathie:—

A. Peculiar to Madagascar.
Melanatria.
Helicophanta (with nearest allied genera in the Oriental Region).
Ampelita.
Clavator.
Kalidos (with nearest allied genera in the Oriental Region).
Bathia (allied to the Oriental *Taphrospira*).

B. Common to Madagascar and the Oriental Region.
Hemiplecta (*v.* Appendix).
Rhysota.

C. Common to Madagascar and the Oriental Region and found sparsely in Africa.
Paludomus.

D. Common to Madagascar and Africa.
Cleopatra.
Urocyclus.
(*Tropidophora*).

The rest of the enumerated genera are cosmopolitan.

In the appended details the twenty-five (out of thirty-two) peculiar species are indicated by an asterisk.

Note.—Since writing this introduction the author has received an interesting communication from Colonel H. H. Godwin-Austen, F.R.S., with reference to the community of species between Madagascar, Mauritius, and India. He draws attention to the fact that an Assamese species of *Macrochlamys* has been introduced into Mauritius with *dhan*, or unhusked rice, exported from Assam, and goes on to say : "I feel quite convinced that India, Madagascar, and the E. coasts of Africa have been in connection with each other by native craft going back 4000 years or more. The Banana has played its part in the transmission of species." Such observations show that caution is necessary in dealing with cases of community of species between the East and West coasts of the Indian Ocean. For a more extended survey of this question, *cf.* Godwin-Austen, Proc. Malac. Soc. 1908, p. 146. The author has to thank Col. Godwin-Austen for valuable assistance and advice in the determination of some of the forms here enumerated.

List of Species.

STREPTONEURA.

1. Neritina gagates, *Lamk.*

Lamarck, An. s. Vert., 1822, p. 185.

Between Tamatave and Marodasatia (Antongil Bay), E. Madagascar.

Representative examples.

So far as can be discovered, this is the first notice of the species from Madagascar, though it has been previously recorded from Mauritius and the adjacent islands.

2. Neritina [Clypeolum] pulligera, *Linn.*, var. Knorri, *Récluz.*

Linné, Syst. Nat. ed. xii. p. 1253.

Locality. Vide no. 1.

A small discoloured example.

This variety, according to examples in the British Museum, extends as far east as the Goram Is. (New Guinea), and is also found in Continental Africa. The species is also found in Australia and C. Polynesia (*Pilsbry*).

3. ? Cleopatra trabonjiensis, *E. A. Smith.*

E. A. Smith, P. Z. S. 1882.

Lake Alaotra, N. end.

Cleopatra multilirata and *Cl. Smithii*, Ancey (Nautilus, xx. 1906, p. 45) are strikingly like this species, and do not appear to differ specifically.

These two forms are from Vinaninony (Madagascar) and the R. Chozi (B. Central Africa).

4. *Paludomus Grandidieri, *Crosse & Fischer*.

Crosse & Fischer, Journ. de Conch. 1872, p. 209.

Locality? (Küster, Conch.-Cab. F. p. 45, gives "streams of E. Madagascar (*Grandidier*)").

5. *Paludomus madagascariensis, *Brot*.

Brot, in Küster's Conch.-Cab. 1880, vol. F.

Locality. Cf. no. 4 (Brot only gives "Madagascar").

This species is represented by a single example slightly differing from the typical form in that the shoulders of the apical whorls are ornamented with a rim.

It would appear that these two species are the only representatives of the genus, which is otherwise restricted to India, and largely to Ceylon. The allied genera *Tanalia*, *Stomatodon*, and *Philopotamis* are essentially Singhalese.

6. *Melanatria fluminea (*Gmelin*).

Gmelin, Syst. 3503, *Buccinum flumineum*.

Torrents between Matilasu and Mangoro (E.), and at source of R. Ihovika (1000 m. alt.).

Lake Alaotra?

Representative examples.

7. *Melanatria Johnstoni, *E. A. Smith*.

Smith, P. Z. S. 1882.

Mahavavy, Bélolóndy (100 m. alt.), and Mahavavy-Tandrahu.

Representative examples.

8. ? Melania psorica, *Morelet*.

Morelet, Journ. de Conch. 1864, p. 287.

Locality?

Represented by a few weathered and incomplete specimens.

Though agreeing in most respects with the figure and description of *psorica*, these examples, however, exhibit an aperture very effuse towards the base. If more material of good condition were forthcoming, it might lead one to consider this a new species, though in any case it is very near *psorica*.

In general this species appears to be allied to the *rudis* group (Ceylon-Amboina).

9. Melania amarula (*Brug.*).

Bruguière, Encycl. Méthod. t. 458, *Bulimus amarula.*

Locality. Cf. no. 1.

Ten examples, all juvenile. The spines in all appear to be rather short when compared with examples of the same age from Mauritius.

According to von Martens, Moll. Maur. 1880, p. 211, the "*Voluta fluviatilis*" of Rumphius from Amboina, compared by Rumphius to Linné's *Helix amarula*, is the same as this species. This gives an eastern extension of the species, which is otherwise known from the Comoros, Bourbon, and Mauritius, and the present locality.

10. Melania tuberculata, *Müller.*

Müller, Verm. no. 378, *Melania tuberculata.*

Locality. Cf. no. 1.

Rather smooth examples with little tuberculation and marked spiral sculpture, the body-whorl rather ventricose.

11. *Tropidophora bicarinata, *Sowerby.*

Sowerby, Thesaurus, vol. i., Cyclostoma, p. 120.

Forest of Folohy.

In woods 300 to 600 m. alt. between Matilavu and Mangoro.

Vide under 12.

12. *Tropidophora betsiloensis, *E. A. Smith.*

Smith, P. Z. S. 1882.

In woods 300 to 600 m. alt., between Matilavu and Mangoro, and near Lake Alaotra.

This species is very near the preceding, and it is possible that further investigation upon a good supply of material would furnish intervening links. As it is, the two species appear to be divisible upon the nature of the umbilicus alone, which is uncovered in *betsiloensis.*

13. *Tropidophora congenera, *E. A. Smith.*

Smith, l. c.

Woods, on limestone soil, Ambongo.

A single weathered example.

This species is, as Smith admits, very closely related to another Malagasy form, *C. consanguineum*, Sowerby.

14. ? *Tropidophora sp. ?

One example from woods on limestone soil, Nomoroko, Ambongo.

This example is very weathered, and precise determination is thus precluded. It appears to be near *T. ligatum*, Müller, though, as far as can be made out, sufficiently distinct.

15. *Tropidophora balteatum, *Sowerby*.

Sowerby, P. Z. S. 1873, p. 452.

One example from woods on limestone soil, Ambongo.

16. *Ampullaria madagascariensis, *E. A. Smith*.

Lake Alaotra.
Ambongo.
Ponds and streams in W. Madagascar.

EUTHYNEURA.

PULMONATA.

Suborder **Basommatophora**.

Fam. Limnæidæ.

17. *Limnæa hovarum, *Tristram*.

Tristram, P. Z. S. 1863, p. 61.

Lake Alaotra.

The examples of this species are all very much eroded, and it is not possible to be quite sure if the sculpture alluded to by Smith (P. Z. S. 1882, p. 385) is present, though traces appear to remain.

L. specularis, Morelet MS. (B.M.) is a synonym.

Suborder **Stylommatophora**.

Fam. Limacidæ.

18. *Urocyclus pinguis, n. sp. (Plate **35**. figs. 6, 7.)

Locality. Vide no. 1 (*v.* Appendix).

This species and the *Veronicella* described below have had names proposed for them in spite of the fact that preservation in alcohol has had the result of discolouring them. Reliance has been placed in the other superficial characters for determining them, with the result that it has been impossible to find any described species with which it is possible to identify them.

Body swollen and stout, moderately carinate, the posterior part of the body traversed by longitudinal grooves which occasionally are bifurcated, and the interspaces between which are marked by smaller grooves set at right angles to them.

Shield rather large, rounded posteriorly, wrinkled and granular, with a small dorsal pore. Tail truncate.

Foot deeply sulcate transversely and its edge thrown into folds † in the posterior region. Anteriorly smooth and non-plicate. The median third about equals the lateral areas in width.

Colour (in alcohol) : very pale dirty yellow, with two lateral bands of faint purplish-brown on the shield.

Length 25·5 mm., breadth 9 mm. Breadth of foot 4·5 mm.

Holotype in the Zoological Department, British Museum.

Fam. Zonitidæ.

19. *Rhysota æquivoca, n. sp. (Plate 35. figs. 16–18.)

Woods, liassic limestone, Ambongo.

The above generic position has been assigned upon the conchological characters specified as generic by Pilsbry (Man. Conch. 2nd series, ii. p. 6), though it is highly probable that more complete anatomical knowledge of the group will lead to a redistribution of the forms assigned to this and the related genera.

Shell very depressed ; spire scarcely salient at all, perforate, shouldered at the beginning of the last whorl ; whorls $5\frac{1}{2}$, gradually increasing in size, the last increasing rapidly. The sculpture is the same above and below, and consists of closely-set and slightly undulating lines of growth finely decussated to give a close granular texture to the surface. Suture impressed. Aperture irregularly lunate, the inferior edge sloping gently down to an expansion occupying the extreme inferior angle ; external superior angle rounded off ; columellar lip slightly expanded over the umbilicus. Peristome a little thickened. Colour very pale dirty yellow, becoming brighter at the peristome and paler in the columellar region.

Dimensions (max.) 35·5 mm. diam. × 16 mm. alt.

Holotype from Ambongo, in the Zoological Department, British Museum.

20. *Kalidos Bournei, n. sp. (Plate 35. figs. 8–10.)

Woods, on limestone soil, "Turingy de Namoroko, Ambongo" (*P. de la B.*).

This is clearly to be included in the genus proposed by Gude (Proc. Malac. Soc. 1911, p. 273) for *Helix ekongoensis*, Angas. At first sight it appears to resemble that species ; but while *ekongoensis* is obviously juvenile, and this species is adult, the latter is smaller, while, in addition, it lacks the exquisite sculpture of Angas's species, is flatter in the spire, and exhibits other differences.

† It is just possible, but not at all likely, that this plication is due to contraction in spirit.

Shell minutely perforated, depressed, thin ; 5¼ whorls ; suture impressed ; the part of the body-whorl above the periphery about the same size as that below ; surface smooth, scarcely marked by the lines of growth. The periphery rounded. Colour yellowish, becoming lighter underneath ; the body-whorl traversed by two spiral chestnut bands, one on the periphery, the other above it; the latter is continued on to the upper whorls. Aperture flattened, lunate, gently curved without any angulation. Columella very slightly reflected over the umbilicus.

Dimensions : 19 mm. (max. diam.) × 11·25 mm. (max. alt.).

Holotype in the Zoological Department, British Museum.

21. *Hemiplecta oleata, *Ancey* (*v.* Appendix).

Hemiplecta oleata, Ancey, Nautilus, 16, p. 65.

Forest of Folohy.

The examples representing this species agree very closely with the type-description, except that the upper surface can scarcely be regarded as entirely "irregulariter granulata," the granulations being in most parts regular and formed by the decussation of spiral striæ on the lines of growth.

22. *Hemiplecta bathensis, n. sp. (Plate 35. figs. 1–3.)

Woods, liassic limestone, Ambongo.

The author experiences considerable diffidence in placing this in the above genus. It resembles *javanica*, Lamk., ranked by Pilsbry (Man. Conch. ser. II. 2, p. 80) along with certain other Indian and Malaysian forms as "connecting [*Xesta*] with *Xestina*," and by Gude (Journ. Malacology, x. 1903, p. 54) as a *Hemiplecta*. Gude's view appears to be the more correct, though, from consideration of examples in the British Museum, it would seem as though *javanica* is not a true *Hemiplecta*, but more probably a form intermediate between the latter and *Xesta*.

Shell perforate, subconoid, thin ; whorls 6, periphery rounded. The closely-set lines of growth decussated by spiral striæ that are sometimes closely gathered and undulating, sometimes scattered and irregular. Aperture without any angulation, rounded, somewhat effuse. Colour white or yellow, the body-whorl traversed by two bright chestnut bands, one at the periphery, the other above it, the latter continued onto the upper whorls. The columella reflected as a short, rather broad-based callus.

Dimensions : 36 mm. (max. diam.) × 22 mm. (max. alt.).

Holotype in the Zoological Department, British Museum, from Ambongo.

23. *Bathia madagascariensis, n. gen., n. sp. (Plate 35. figs. 11–13.)

It is only after considerable hesitation that the author has decided to assign a generic position to the single representative specimen.

It is clearly unlike any species described hitherto either from Madagascar or the adjacent regions, Ethiopian or Oriental. At first sight the author was inclined to consider it a *Taphrospira*, as its generic affinities clearly lie in that direction; but inasmuch as conchological evidence is alone available, it has seemed better to give it generic rank rather than associate it with a genus of which a clearly-defined conception founded upon anatomy has been formed, and to which its resemblances are at the best only general.

Bathia, n. gen.

Shell in general form resembling that of *Taphrospira*, but with the apical whorls flattened down to the level of the body-whorl, yielding a perfectly horizontal apical region, and the body-whorl quadrate in outline; suture deeply channelled; minutely perforate.

Bathia madagascariensis, n. sp.

Shell thin, subpellucid, very pale yellow; whorls $6\frac{1}{4}$, those of the apex depressed and flattened to the level of the body-whorl, the suture deeply and widely channelled; sculptured with numerous extremely fine spiral striæ, intercepted by lines of growth. Aperture lunate, with a depression above corresponding to the channelled suture and forming an acute upper angle; columellar lip very slightly reflected over the umbilicus. When viewed in profile the body-whorl is seen to be very little rounded, horizontal below, and remarkably wide in comparison to its depth.

Genotype in the British Museum (Zoological Department).

From woods on limestone, Namoroku (Ambongo).

Dimensions: alt. 9·75 mm., diam. 19 mm.

A knowledge of the anatomy of the forms in question can only yield a satisfactory answer; but it may eventually be found that Férussac's *Helix prætumida* (Seychelles and Mauritius) and Morelet's *H. cyclaria* (Mauritius) fall into the group of this genus and *Taphrospira*.

Fam. Vaginulidæ.

24. *Veronicella hovarum, n. sp.† (*v.* Appendix). (Plate 35. figs. 4, 5.)

Locality (see no. 1).

Body elongate, oblong, anterior and posterior ends equally rounded off, rather markedly arched, as much distended below the mantle-edge as above it; mantle-edge acute. Foot separated from body by a well-marked groove, plicate transversely and, in addition, subdivided by numerous thin ridges which are often themselves subdivided, and the edges of which are frequently frilled, posteriorly rounded, anteriorly squarely truncate, slightly tapering

† *Cf.* no. 18.

towards the extremity. Posterior tentacles dark grey, transversely wrinkled; anterior tentacles pale, slightly bifid at the extremity.

Colour (in alcohol) : the skin of the dorsal surface, which is covered with minute irregular papillæ and sparsely traversed by meandering seams, is dark bluish grey, becoming dull purplish yellow anteriorly. The median line is occupied by a thin yellow stripe, which falls 2 or 3 mm. short of the end of the body posteriorly and is lost anteriorly. The under surface is the same as the upper near the mantle-edge, but becomes paler near the foot, which is dull yellow.

Length (in alcohol) 33 mm.; breadth 14 mm.; width of sole 5 mm.

Type in the Zoological Department, British Museum.

Fam. HELICIDÆ.

25. *HELICOPHANTA SOUVERBIANA, *Fischer*.

Fischer, Journ. de Conch. 1860, p. 210.

Woods, 300–600 m. alt., on gneiss rocks, Mangoro and Matitona (E.).

26. *HELICOPHANTA BICINGULATA, *E. A. Smith*.

E. A. Smith, P. Z. S. 1882.

N. centre (plateau, about 1000 m. alt.).

27. *HELICOPHANTA METHUENI, n. sp. (Plate 35. figs. 14, 15.)

Liassic limestone, Ambongo (W.).

Erect, pyriform, imperforate; whorls nearly 5, the last very large. Aperture suboblique, rounded below. The columellar lip perpendicular and forming a flat triangular callus over, but not closing, the umbilicus. Peristome narrow, a little reflexed. The umbilical region markedly effuse. Growth-lines, as in *H. phenax*, decussated by spiral striæ, but even in rather worn examples not nearly so closely. Colour of the inferior half of the body-whorl ? pale yellow or ochreous, traversed by a brown band, the upper half and apical whorls of a yellowish brown, delimited from the inferior lighter area on the body-whorl by a second brown band.

Akin to *H. phenax*, Pilsbry, but distinguished clearly by the character of the columellar lip and umbilical region, the more acute apex, and probably by the texture.

Max. alt. 61 mm.

Holotype in the British Museum (Zoological Department), from Ambongo.

28. EULOTA SIMILARIS, *Féruss.*

Férussac, Hist. nat. Moll. i. p. 171.

Locality. Cf. no. 1.

This species, as is now well known, has been distributed throughout the tropics in the soil adhering to coffee-plants.

29. *Ampelita sepulchralis, *Féruss.*

Férussac, Hist. nat. Moll. i. p. 51.

Anamalagotra and Tamatave-Marodasatia.

30. *Ampelita xystera, *Pfeiff.* (after Valenciennes, n. n.).

Helix novacula, v. Martens, Nov. Conch. 1879, vol. v. p. 181.
H. lanx, var., Férussac, Hist. nat. Moll. i. p. 357, pl. 62. figs. 8, 9, 10 (1850).
H. xystera, Pfeiffer, Symbolæ, 1841, p. 41 (after Valenciennes, n. n.).
? *Ampelita Shavi*, E. A. Smith. P. Z. S. 1882.

Tamatave-Marodasatia.

Woods, liassic limestone, Ambongo.

Woods, gneiss, Mangoro-Matitanavu, 300–600 m. alt.

I did not think such a synonymy were possible; but upon supplementing Mr. Methuen's material with shells from the British Museum and others kindly lent by Mr. J. H. Ponsonby, it became obvious that all the forms indicated grade into each other by imperceptible degrees.

Fam. Stenogyridæ.

31. *Clavator clavator (*Petit*).

Bulimus clavator, Petit, Revue Zool. 1844, p. 3.

Near R. Mangóky (S.E.). Woods, limestone soil.

32. *Clavator eximius (*Shuttleworth*).

Spiraxis eximia, Shuttleworth, Mittheil. Bern. naturf. Ges. 1852, p. 208.

Between Matitanu and Mangoro (E.); woods, 300–600 m.

As Pilsbry (Man. Conchology, ser. II. vol. xvii. p. 193) remarks, the relation of *Clavator* to other genera cannot be intelligently discussed until the soft parts are investigated. In addition, "the species resemble several diverse groups in other regions. *C. obtusatus* has a Stenogyroid contour, *C. Grandidieri* is Placostyloid, and *C. Balstoni, eximia*, &c. resemble *Thaumastus*" (Pilsbry, *loc. cit.*). Mr. T. Iredale, in addition, informs me that *C. eximia* has often been taken for *Placostylus Bollonsi* (New Zealand) at first sight. It is possible that this group is polyphyletic, and that anatomical knowledge will serve to discriminate the various elements.

Appendix. [June 3rd, 1914.]

Since the foregoing account was drawn up some twelve months ago sundry delays have hindered its publication. The author therefore avails himself of the present opportunity to remedy in some small measure the deficiency of

information respecting the anatomy of the forms under discussion. The chief item of interest in these additions is the fact that dissection of the form diagnosed on conchological grounds and named *Hemiplecta oleata* by Ancey (no. 21) has resulted in the discovery that it is not referable to *Hemiplecta*, but appears to occupy a position near *Rhysota*.

Additions to the preceding account are given below, and figures have been incorporated in the text.

Methvenia, n. gen.

Foot-sole undivided, a large vertically-directed caudal mucous pore. The penis and epiphallus are long and narrow; the vas deferens is also very long and bears an elongate cylindrical flagellum placed at a considerable distance from the epiphallus; vagina elongate. Jaw simple, with a median projection. Radula having the marginal teeth long, unicuspidate, almost straight, and furnished with a deeply excavated base. "Shell large, globose-depressed, thin, with the surface irregularly granulated above, and having the fine growth-lines decussated by sinuous spiral lines below" (*Ancey*).

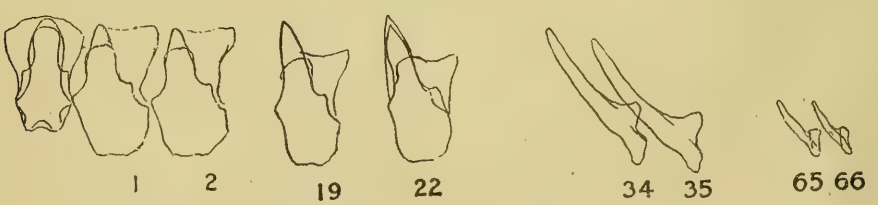
Methvenia oleata (*Ancey*) (*v.* no. 21, *antea*).

The *mantle*, on removing the shell, is found to be pale, with numerous dark brown and white flecks, and a number of elongated dark lines extending transversely across the mantle from the intestinal area.

The *foot* is *probably* chestnut-brown in colour. It exhibits a very narrow and partly evanescent peripodium, and a deep, vertically placed, caudal mucous pore which bears two lateral extensions which impart a cruciform shape to the pore. The latter character may be due to contraction in spirit. Burne (Proc. Malac. Soc. ix., 1910) has described a similar appearance of the mucous pore in *Rhysota Fouilloyi*. The foot-sole is undivided.

The precise interpretation of the *mantle-lobes* is uncertain as yet. There appear to be only a right cervical lobe, which encircles the pneumostome, and a subdivided left cervical lobe, a condition like that seen in *Rhysota* (*cf.* Burne, *loc. cit.*).

Fig. 1.



Radula of *Methvenia oleata* (Ancey). (Reichert, 4 oc. × 6 obj.)

The *jaw* (fig. 2) is simple, but remarkably thick. It bears a well-marked median projection.

The *radula* (fig. 1) exhibits a formula as follows :—

?50. ?20. 1. 20? 50? =141.

The transition between the lateral and marginal teeth is, as usual in these forms, difficult to determine, so that the relative numbers constituting each series must be left subject to query.

The distinctive feature of the radula is the series of long, acute, and almost straight marginals, which much resemble those figured for *Rhysota Fouilloyi* by Burne (*v. antea*). Such teeth are of course met with in other genera (e. g. *Ariophanta*), but never to the author's knowledge in combination with the precise median and laterals here figured.

Fig. 2



Fig. 3.

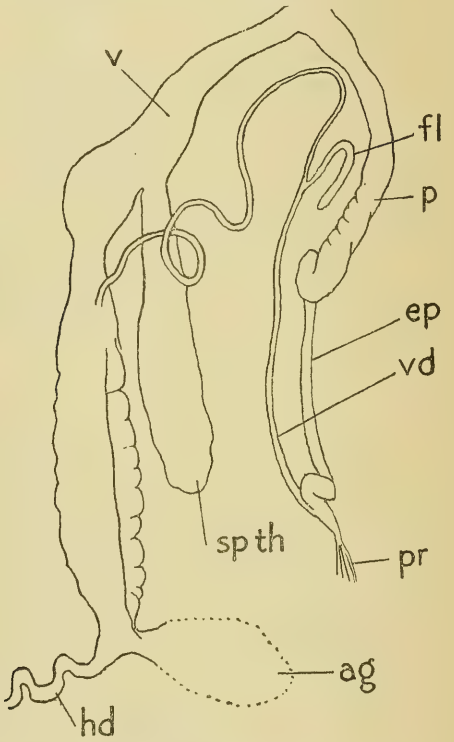


Fig. 2. Jaw of *Methvenia oleata* (Ancey). (Reichert, 2 oc. × 3 obj.)

Fig. 3. Genitalia of *Methvenia oleata* (Ancey). *p*, penis; *ep*, epiphallus; *pr*, penis retractor; *vd*, vas deferens; *fl*, flagellum; *v*, vagina; *spth*, spermatheca; *hd*, sperm-oviduct; *ag*, albumen-gland.

The *genitalia* (fig. 3) are characterized by the long narrow penis and epiphallus, and also by the cylindrical flagellum borne on the very long and winding vas deferens at a considerable distance from the epiphallus. In the female organs the distinctive feature is the length of the vagina.

The *kidney* is characteristic in being long and relatively very broad, and in having its distal extremity curved.

The association of characters above enumerated is not found in any other Zonitoid genus the author is familiar with, and the works of Godwin-Austen, Semper, &c. have been searched in vain. Clearly allied to *Rhysota,* and possibly *Ariophanta*, it nevertheless appears to be generically distinct.

Veronicella hovarum, n. sp. (*v. antea*, no. 24).

The *radula* (fig. 4) has the formula :—

? 17. ? 34. 1. ? 34. ? 17. = 105.

The teeth are closely crowded and the base of the central tooth is obscured by the internal angles of the first laterals. The rows of teeth are disposed in an undulating pattern, each half-row slanting forward from its central tooth until about the fortieth tooth, and then commencing a backward slant.

The *jaw* (*cf.* fig. 5) is remarkably wide. It exhibits four or five broad overlapping plates at each extremity, while the median plates are more narrow and fibrous.

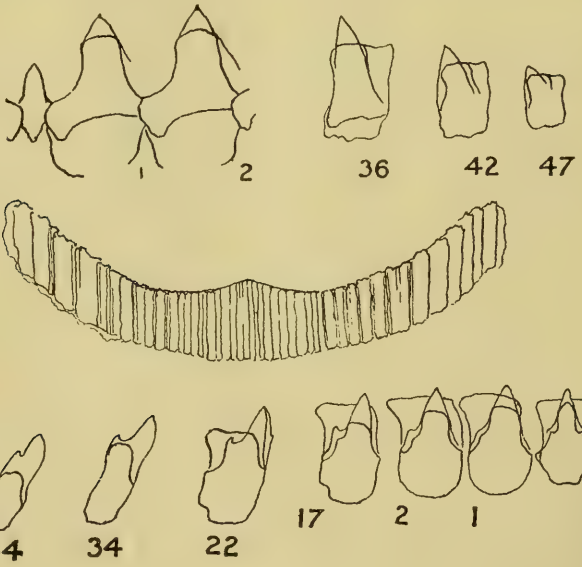


Fig. 4.

Fig. 5.

Fig. 6.

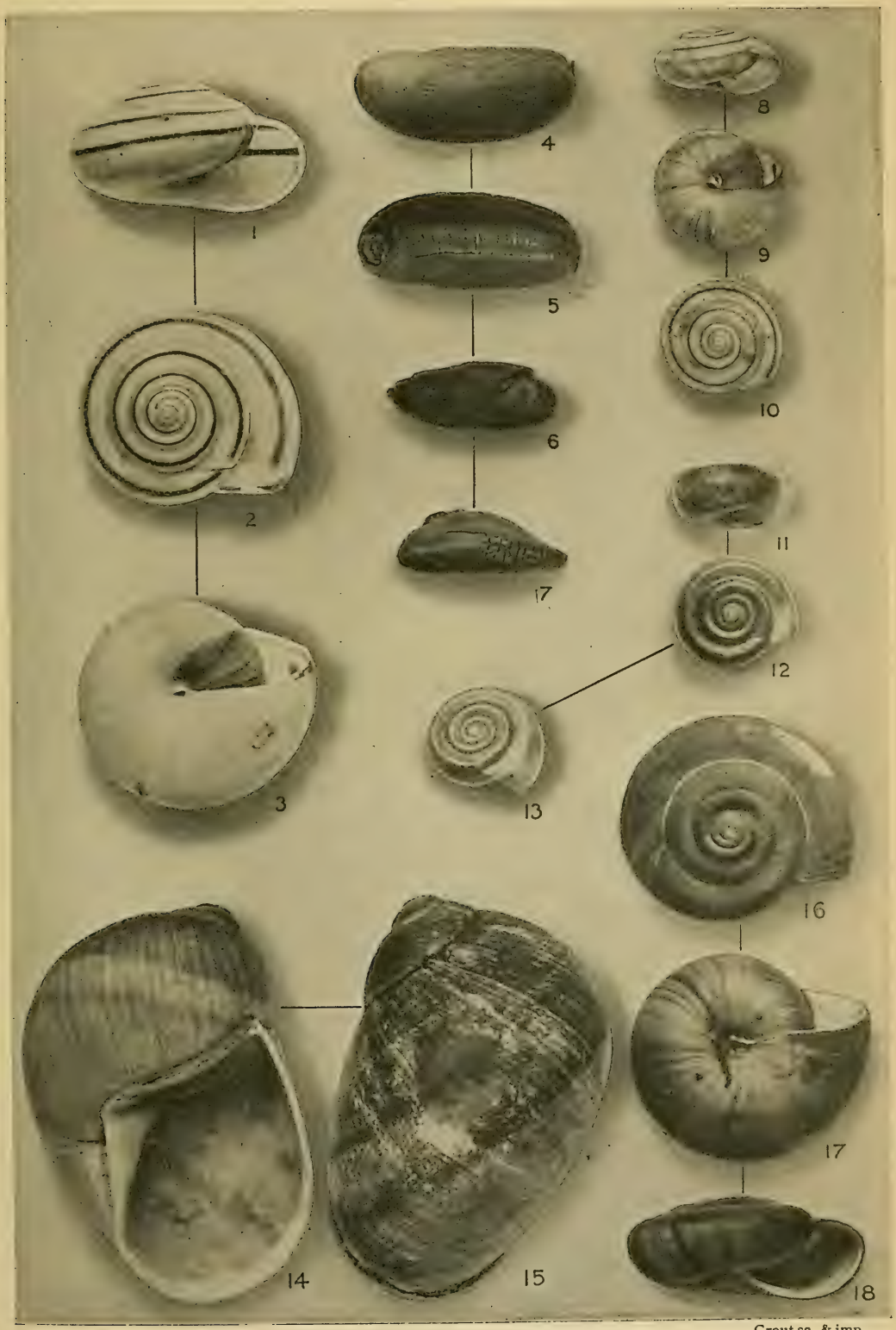
Fig. 4. *Veronicella hovarum.* Radula. (Reichert, 4 oc. × 6 obj.)
Fig. 5. *Veronicella hovarum.* Jaw. (Zeiss bin., 2 oc. × F. 55 obj.)
Fig. 6. *Urocyclus pinguis.* Radula. (Reichert, 4 oc. × 6 obj.)

Urocyclus pinguis, n. sp. (*v. antea*, no. 18).

The *radula* (fig. 6) has the formula :—

? 36. ? 17. 1. ? 17. ? 36. = 107.

The central tooth has a peculiar tendency towards asymmetry, the lateral cusps shown in the drawing being frequently disposed at different heights from the base.



Grout sc. & imp.

GASTROPODA FROM MADAGASCAR.

EXPLANATION OF PLATE 35.

Figs. 1, 2, 3. *Hemiplecta bathensis*, n. sp.
Figs. 4, 5. *Veronicella hovarum*, n. sp.
Figs. 6, 7. *Urocyclus pinguis*, n. sp.
Figs. 8, 9, 10. *Kalidos bournei*, n. sp.
Figs. 11, 12, 13. *Bathia madagascariensis*, n. gen., n. sp.
Figs. 14, 15. *Helicophanta methueni*, n. sp.
Figs. 16, 17, 18. *Rhysota æquivoca*, n. sp.

W. A. Lamborn's Breeding Experiments upon *Acræa encedon* (Linn.), in the Lagos District of West Africa, 1910–1912.

By Edward B. Poulton, D.Sc., F.R.S., Pres.L.S.

[Read 2nd April, 1914.]

The typical form of *Acræa encedon* is a tawny butterfly with a black, white-barred tip to the fore wing. The pattern thus closely resembles that of the type form of *Danaida chrysippus*, Linn. *A. encedon* is polymorphic in both sexes, and the following forms are referred to in the present memoir :—

Infuscata, Staud., "the tawny areas of the typical forms are replaced by smoky brown" (p. 112*). This form is transitional in one direction into dark-grey butterflies without any tawny tint, and in the other into dark forms of *encedon*.

Alcippina, Auriv. "The h.-w. has a white central suffusion of varying extent" (p. 212), thus reproducing the pattern of the *alcippus*, Cram., form of *chrysippus* and of transitional varieties between *alcippus* and *chrysippus*.

Daira, Godm. & Salv., "the black of apical half of f.-w. and the white subapical band are absent. In some cases the subapical band may be traced as a slightly paler area on the ground-colour. All the black markings much reduced" (p. 212).

Commixta, Poulton †. This form is a combination of the two preceding, having the central white patch on the hind wing of *alcippina*, and a fore wing approaching that of *daira* in the tint of the subapical bar, which is tawny like the ground-colour. The pattern thus resembles the *albinus*, Lanz, form of *chrysippus*, but the mimetic relationship is not suggested because of the rarity of the model and its restriction to the parts of Africa where *dorippus* is abundant.

Lycia, Fabr. "The ground-colour of both wings is white, the black markings being as in the typical form" (p. 112). "Examples of the *lycia* form may have the ground-colour pale creamy yellow" (p. 213), and are thus transitional towards the *sganzini* form.

Sganzini, Boisd. "The tawny areas of the typical form are replaced by a dusky yellowish colour" (p. 212).

* This description and those of the other forms except *commixta* are quoted from H. Eltringham's great work, "Monograph of the African Species of the Genus *Acræa*," Trans. Ent. Soc. Lond. 1912, pt. i.

† Trans. Ent. Soc. Lond. 1913, p. 409.

The Geographical Distribution and Mimetic Associations of the forms of Acræa encedon.

The account contained in the following four paragraphs was drawn up by the present writer in 1907 but has not hitherto been published.

Acræa encedon, like the female of *Hypolimnas misippus* (Linn.), presents three forms mimicking the three forms of *Danaida chrysippus* (Linn.), but, being without the extraordinary powers of flight possessed by the Nymphaline co-mimic, their geographical coincidence with the forms of the model is closer. This superiority is particularly interesting in relation to Müllerian mimicry when we remember that the *Acræinæ* are a highly protected group.

In South Africa the predominant form is *encedon*, resembling the predominant *chrysippus*. Dr. Dixey and Dr. Longstaff, from their experience of it in this part of the Region, state that *encedon* was "so successful in its mimicry of *L. chrysippus* as at first to make one of us believe it to be that species".* There is also a black and white form, *lycia*, F., and, even more commonly, a black and yellowish form (*sganzini*, Boisd.) which occur not only here but throughout the East Coast range of *encedon*. Mr. Marshall has recorded that *lycia*, when upon the wing, shows a decided resemblance to the whiter forms of *Acræa esebria*, Hew.†

As we pass northwards, forms with white hind wings (*alcippina*, Auriv.) and forms in which the black and white tip to the fore wing is evanescent (*daira*, Godm. & Salv.), both rare in the South, begin to increase in numbers, intermixed with the type *encedon*. Finally, in British East Africa, all three forms occur commonly, *daira* and *encedon* being most abundant, just as are the corresponding models—the *dorippus*, Klug, and type forms of *D. chrysippus*.

In the West, all forms except *sganzini* occur, but the late Mr. Herbert Druce, F.L.S., received ‡ from a locality in Sierra Leone several specimens of *alcippina*, which seem to show that the *alcippus* form of *D. chrysippus* has here at least produced some effect as a model. The specimens in Mr. Druce's series are not only all *alcippina* but unusually pronounced examples of this form, and beautiful mimics of the tropical West African form of *D. chrysippus*.

H. Eltringham remarks of the distribution of *encedon*: "None of the forms seems to be specially characteristic of any particular locality, though the *alcippina* form seems to attain its maximum development in West Africa" (*l. c.* p. 213). "The *lycia*, *alcippina*, and *infuscata* forms are more numerous in West African localities than elsewhere, though they seem liable to occur elsewhere" (p. 211).

* Trans. Ent. Soc. Lond. 1907, p. 318; also p. 328. See also p. 321 for the converse mistake, viz. of model for mimic.

† Trans. Ent. Soc. Lond. 1902, p. 479.

‡ Trans. Ent. Soc. Lond. 1902, p. 480. The *daira* form is *extremely* rare in the West.

Since the appearance of Eltringham's monograph much evidence has accumulated proving beyond doubt the strong development of the white-hind-winged *alcippina* form in the interior of Sierra Leone, from which area it is probably continuous into N. Nigeria. The following list of examples of *alcippina* and its model *alcippus*, recently received by the British Museum of Natural History, has been kindly prepared by Mr. N. D. Riley, F.E.S. The extraordinary predominance of the female *alcippina* over the male—50 to 5—strongly suggests the prevalence of all-female families such as Mr. W. A. Lamborn finds in the Lagos district.

Dated examples of Danaida chrysippus, f. alcippus, *and* Acræa encedon, f. alcippina *in the British Museum, from Sierra Leone and N. Nigeria.*

I.—Sierra Leone. Collected by J. J. Simpson.

		D. chrysippus, f. *alcippus*.		*A. encedon*, f. *alcippina*.	
Kambia.	24. iii. 1912.	14♂	—	—	—
Bassia.	25. iii. „	5♂	—	—	—
Kokona.	26. iii. „	5♂	—	—	—
Yana.	30. iii. „	1♂	—	—	—
Laminaia	23–25. iv. „	1♂	—	—	—
Port Lokko.	9–11. v. „	1♂	1♀	—	—
Batkam.	15–18. v. „	8♂	5♀	—	—
Kafogo.	23. v. „	5♂	2♀	—	1♀
Kaballa.	27. v. „	4♂	—	—	1♀
Benikoro.	30. v. „	—	—	—	1♀
Falaba.	1. vi. „	—	1♀	—	1♀
Tirikoro.	15–17. vi. „	—	—	1♂	1♀
Keneura.	20. vi. „	—	—	—	1♀
Bumbanya.	22. vi. „	1♂	—	—	—
Johanna.	28. vi. „	1♂	—	—	—
Giema.	6. viii. „	—	—	1♂	—
Jowati.	19. viii. „	—	—	—	1♀
Gigbema.	22. viii. „	—	—	1♂	38♀
Bo.	1. ix. „	4♂	3♀	—	—
Mafwe.	7. x. „	5♂	—	—	2♀
II.—N. Nigeria. Collected by G. T. Fox.					
Panyam.	2. vi. 1910.	—	2♀	—	—
(Banchi Prov.).	3. vi. „	—	—	1♂	1♀
	4. vi. „	—	1♀	1♂	1♀
	31. vii. „	—	—	—	1♀
	13. viii. „	1♂	—	—	—
Totals		56♂	15♀	5♂	50♀

In addition to the above, the British Museum Collection contains a single undated female *alcippina* from Panguma, N. Nigeria, another undated female from 70 miles up the river from Freetown, Sierra Leone, and an undated male from Liberia.

The predominant development of *alcippina* in Sierra Leone will be rendered evident by the following list of the other West African forms of *encedon* in the British Museum, also prepared by Mr. N. D. Riley, together with all West African forms, including *alcippina,* in the Hope Department, Oxford, and the Tring Zoological Museum :—

Localities and Museums. I. British Museum. II. Hope Department.[1] III. Tring Museum.		*encedon.*	*encedon infuscata.*	*infuscata.*	*alcippina.*	*daira.*	*commixta.*	*lycia.*
Gambia River ...	III.							1♂ 2♀
Sierra Leone	I.			1♂[2]			2♂ 2♀	4♀
	II.				1♀[3]			1♂ 1♀
	III.				1♀			3♀
Gold Coast	I.							1♂
Nigeria, N. & S....	I.			2♂ 20♀		1♂[4]	3♂ 1♀	5♂ 17♀
	II[5].		1♂	7♂ 2♀[6]	1♂[7]		1♂ 1♀	7♂[8] 5♀
	III.							2♀
Cameroons.....	I.	1♂		1♀				
	III.				1♀			
Congo State	I.	2♀[9]						
	II.		2♀	2♂[10]				2♂
	III.		2♂ 7♀		1♀			1♂ 1♀
Angola	I.	1♀						1♀
	II.		1♀					
	III.		21♂[11] 6♀					7♂ 3♀
Totals		1♂ 3♀	24♂ 16♀	12♂ 23♀	1♂ 4♀	1♂	6♂ 4♀	25♂ 39♀

[1] Including a few specimens from the collections of M. Charles Oberthür and of the Luxembourg Museum, which I have had the opportunity of studying at Oxford.

[2] Transitional towards *lycia.*

[3] Port Lokkoh : 1912 : Mrs. Addison.

[4] The type of the form, from Lower Niger.

[5] Not including the captured parents of any of the families tabulated on pp. 407, 409–414.

[6] The ♀♀ very dark : one ♂ with a fulvous f.-w. bar.

[7] Ibadan, S. Nigeria : May 1910 : Rev. Lake S. Noble.

[8] Included in the 7♂♂ is an injured specimen of which the sex is not quite certain.

[9] One ♀ is the type of "*fulva,*" Doubl., Westw., and Hew.

[10] Very dark specimens

[11] One ♂ transitional towards *alcippina.*

The relative proportion of males and females suggests the prevalence of all-female families, especially in Nigeria. The figures from Old Calabar, included in the Nigerian totals from the British Museum (I.), are remarkable :—18 ♀ *infuscata*, 1 ♀ *commixta*, 14 ♀ *lycia*.

The two lists confirm Eltringham's conclusions as to the West African forms quoted on p. 392. The second list also shows the excessive rarity of *daira*, the predominance of *lycia*, and, next to it, *infuscata* and *infuscata-encedon*, followed by *commixta*. The two lists together show that *alcippina* is rare except in Sierra Leone.

The nearest approach to the proportion of the *encedon* forms on the West coast, S. of Sierra Leone, is to be found in Madagascar, where the pale form *sganzini* is predominant like the still paler *lycia*, and a dark dull form of *encedon* represents *infuscata*. The Madagascan *sganzini* are transitional into a cream-coloured *lycia*. I have not seen any form from Madagascar except those above-named and intermediates between them.

In the Hope Department there are 15 ♂ and 3 ♀ of *sganzini* (1 ♂ might be called a cream-coloured *lycia*), and 6 ♂ 1 ♀ of *encedon-infuscata* (1 ♂ showing transition towards *sganzini*); in the Tring Museum 9 ♂ and 1 ♀ of *sganzini*; in the British Museum 4 ♂ and 1 ♀ of *sganzini*; in the Luxembourg Museum 1 ♂ and 1 ♀ of *sganzini* and 1 ♂ transitional between *sganzini* and *infuscata*.

On the opposite East coast of the continent the pale forms are chiefly *sganzini*, like Madagascar, but their proportion is very different, being much less than that of *encedon*. Thus there are 15 *encedon* and 4 *sganzini* from Natal in the Hope Department. The *lycia* of the West is replaced by the yellower *sganzini*, somewhere about the Rift Valley, in British East Africa.

The much larger amount of material now available supports the conclusions, arrived at in 1907 (p. 392), as to the geographical relationship between certain forms of *encedon* and those of *D. chrysippus*. The form *daira* is common where *dorippus* is common, and becomes rare where *dorippus* is rare or wanting : the typical, brightly coloured *encedon* is predominant where the type form of *chrysippus* prevails : the only locality where *alcippina* is abundant is part of the area over which *alcippus* displaces every other form of *D. chrysippus*. Mimicry occurs in both sexes, although the female, at least in the *encedon* form, is a better mimic than the male, partly on account of its larger size but also because of the whiter subapical bar to the fore wing.

The Forms of Acræa encedon *in the Locality of the Breeding Experiments.*

The following specimens, captured by Mr. W. A. Lamborn in the Oni district, about 70 miles east of Lagos, are included in the Table on p. 394. From Oni : 1 ♂ 2 ♀ *lycia*, 1 ♀ *infuscata* ; from Idakun, 4 miles N.W. of Oni: 4 ♂ *infuscata*, 1 ♂ 1 ♀ *commixta*, 1 ♂ 1 ♀ *lycia*. To these must be added

the captured parents of Families 1, and 3–16, recorded on pp. 407, 409–414, viz. 2 ♂ 7 ♀ *lycia*, 1 ♂ 3 ♀ *infuscata*, 1 ♀ *commixta*, from Oni; 1 ♂ 1 ♀ *lycia*, 1 ♀ *infuscata*, from Idakun. The totals from the Oni district are therefore 16 *lycia* (5 ♂ 11 ♀), 10 *infuscata* (5 ♂ 5 ♀), and 3 *commixta* (1 ♂ 2 ♀).

The artificial conditions produced no apparent effect, the *lycia*, *infuscata*, and *commixta* of the breeding experiments being similar to the captured specimens of the same forms. The families were examined by Eltringham, who states that "the majority consist of two forms, viz. *infuscata* and *lycia*. The latter are somewhat unusual in having broad suffused orange internervular markings on the hind margin of the secondaries on the under side, also some basal markings of the same colour" (*l. c.* p. 213). It is also noticeable that the males of these Southern Nigerian *lycia* are distinctly yellower than their females, and that the subapical bar of the fore wing in the *infuscata* forms is yellow in the male, white in the female. Lamborn concludes that *lycia* is certainly three and probably four times as numerous as *infuscata* in the neighbourhood of Oni, and his material shows that *commixta* is much rarer than *infuscata*. He did not meet with any other form except these three, nor did any other appear in his long series of breeding experiments.

Tabular Statement of W. A. Lamborn's Breeding Experiments (pp. 397–8).

It will be observed that Companies 5 and 7, together with Family 8, suggest that *lycia* and not *infuscata* is dominant, a conclusion rendered improbable by the rest of the figures. These 3 sets, together with Family 7, are probably to be explained by comparison with Families 4 and 13. The *lycia* ♀ parents of these two families laid eggs in two batches, which were kept distinct, and the larvæ reared separately. Both families as a whole yield approximate equality of *infuscata* and *lycia*, but the constituent batches depart widely from this ratio. The 4 irregular results referred to above are all manifest in relatively small numbers, and they may be fairly referred to the causes which produced the constituent batches of Families 4 and 13.

The inferences as to the Mendelian constitution of the parents were submitted to my friend Mr. L. Doncaster, who has had so wide an experience in this line of research. He kindly wrote, April 16, 1913:—

"I think *lycia* must be recessive in spite of the inverted 3 : 1 cases, because of Family 2. Both parents were from Company 4, and if *lycia* were dominant all the *lycia* individuals would presumably be heterozygous. I think all your inferences as to parentage are correct."

Mr. Doncaster also remarks:—"It is a pity there are no known cases of *infuscata* ♀ × *lycia* ♂ and *vice versa*, which would test whether the *infuscata* character is sex-limited in the ♀; but as none of the mixed families have all the ♂ ♂ *infuscata* and ♀ ♀ *lycia*, it does not seem likely."

The results of breeding the Wild Larvæ, the Companies, and Families 1–3 have been recorded in Proc. Ent. Soc. Lond. 1911, pp. liv–lvi, before the appearance of Eltringham's monograph, containing a thorough account of all the forms of *A. encedon*. The darker forms found and bred at Oni, named *encedon* in the 1911 publication, are now recognised as *infuscata*, and a few as *commixta*.

Source of the Broods, with the forms of the parents when known.	*INFUSCATA*, with a few *COMMIXTA*.		*LYCIA*.		Inferred Mendelian constitution of the Parents. Remarks.
	Male.	Female.	Male.	Female.	
Wild Larvæ (1)	6	8	5	26	Two ♂♂ & 1 ♀ *commixta* and 1 transitional ♂ are included among the *infuscata*. The 27 latest emergences were all ♀.
„ „ (2)	...	17	3	18	One ♀ *commixta* is included among the *infuscata*. The 3 ♂♂ appeared with 2 ♀♀ in the 5 latest emergences.
Company 1	...	...	46	32	Both parents recessive (*lycia*). Two ♂♂ approach *commixta*.
„ 2	...	24	...	23	One parent heterozygote (*infuscata*), the other recessive (*lycia*).
„ 3	...	35	...	...	One parent dominant (*infuscata*), the other either dominant, heterozygote (*infuscata*), or recessive (*lycia*).
„ 4	6	2	4	1	One parent heterozygote (*infuscata*), the other recessive (*lycia*).
„ 5	...	6	...	16	The proportions, suggesting heterozygote *lycia* for both parents, are more probably due to a special batch of ova. (See Fams. 4 & 13.)
„ 6	...	...	3	3	Both parents recessive (*lycia*).
„ 7	2	1	7	6	Inference as in Co. 5.
Fam. 1. ♂♀ *lycia*	...	...	...	48	Both parents recessive.
„ 2. ♂♀ *lycia* fr. Company 4...	...	...	19	13	Both parents recessive. One ♂ approaches *commixta*.
„ 3. ♀ *infuscata* ...	5	11	6	13	The ♀ parent heterozygote, the ♂ recessive (*lycia*).
„ 4. ♀ *lycia*	...	33	...	36	The ♀ parent recessive, the ♂ heterozygote (*infuscata*). Eggs in 2 batches, yielding very different proportions.
„ 5. ♂♀ *infuscata* ...	...	28	...	...	One parent dominant, the other dominant or heterozygote. ♀ parent with fulvous subapical bar inherited by 13 offspring, of which 2 approach *commixta*.

Source of the Broods, with the forms of the parents when known.	*INFUSCATA*, with a few *COMMIXTA*.		*LYCIA*.		Inferred Mendelian constitution of the Parents. Remarks
	Male.	Female.	Male.	Female.	
Fam. 6. ♀ *infuscata* ...	...	21	...	21	The ♀ parent heterozygote, the ♂ recessive (*lycia*). A single ♂ *lycia*, perhaps accidentally introduced, is not included.
„ 7. ♀ *commixta*...	...	3	...	9	The 3 ♀♀ in 2nd column are *commixta*. Inference as in Co. 5: 2 heterozygote *lycia* parents are here excluded.
„ 8. ♀ *lycia*	...	7	...	21	Inference as in Co. 5.
„ 9. ♀ *lycia*	...	1	...	1	The ♀ parent recessive, the ♂ heterozygote (*infuscata*).
„ 10. ♀ *lycia*	...	...	...	12	Both parents recessive (*lycia*).
„ 11. ♀ *infuscata*...	...	12	...	14	The ♀ parent heterozygote, the ♂ recessive (*lycia*).
„ 12. ♀ *lycia*	...	...	...	41	Both parents recessive (*lycia*).
„ 13. ♀ *lycia*	...	45	...	42	The ♀ parent recessive, the ♂ heterozygote (*infuscata*). Eggs in 2 batches, yielding different proportions.
„ 14. ♂♀ *lycia*	...	...	...	19	Both parents recessive.
„ 15. ♂♀ *lycia*	...	...	...	19	„ „ „
„ 16. ♂♀ *lycia*	...	...	12		„ „ „
„ 17. ♂♀ *lycia*	...	...	...	34	„ „ „
„ 18. ♂♀ *lycia*	...	...	...	11	„ „ „
„ 19. ♂♀ *lycia*	...	...	24	16	„ „ „
„ 20. Parents unknown	...	35	...	36	One parent heterozygote (*infuscata*), the other recessive (*lycia*).
„ 21. „ „	16	5	...	...	One parent dominant (*infuscata*), the other dominant, heterozygote (*infuscata*), or recessive (*lycia*).
TOTALS	35	294	129	539	

Segregation into infuscata, commixta, *and* lycia.

Looking at the 998 bred specimens * as a whole, it is remarkable how completely they segregate into *infuscata*, *commixta*, and *lycia*, and how few specimens can be considered as intermediate between these. Those that did

* Including the single ♂ which appeared in Family 6.

appear are transitional between *commixta* and *infuscata* on the one side, and *commixta* and *lycia* on the other, rather than directly between the two chief forms. Hence, by selecting the examples, a fair transition from *infuscata* to *lycia* may be constructed by way of *commixta*. This latter form is clearly hereditary. Thus the female parent of Family 7 is *commixta*, and all 3 of her non-*lycia* offspring are *commixta*. Particularly interesting in this respect is Family 5, of which the female parent possesses the fulvous bar but not the white hind wing of *commixta*. About half of the offspring, namely 13 out of 28, resemble the mother in this respect *, while 2 of them have also the white hind wing. Other evidence of the hereditary transmission of this combination of characters will be found under Family 2 (pp. 407–8).

Families of which the female parent only is known.

When the only known parent is a female *infuscata* (or *commixta*) the offspring show, in all four families, a mixture of *infuscata* (or *commixta*) and *lycia* with approximate equality three times. In the single exception, Family 7, the numbers are small. The inference is that one parent was recessive and the other heterozygote.

When the only known parent is a female *lycia*, the offspring are all *lycia* twice and mixed *lycia* and *infuscata* four times, with equality thrice (including the small Family 9) and irregularity once (Family 8).

In the absence of selective breeding, for which there is insufficient evidence, the great numerical superiority of *lycia* would result in the majority of the pairings being between males and females of this form, or between *lycia* and *infuscata*, the latter being far more commonly heterozygote than pure dominant. We can thus, on the hypothesis that *lycia* is recessive, understand why the families bred from a female of this form were either all *lycia* or mixed *lycia* and *infuscata*, but, owing to the relative rarity of the pure dominant, never, in the author's experience, entirely made up of heterozygotes bearing the appearance of the dominant (*infuscata*). It is unfortunate that the *infuscata* in the families with equal numbers of the two forms never happen to have been bred from, so that their heterozygote constitution could be tested.

Families of which both parents are known.

Both male and female are of the form *lycia* in 8 families; both are of the form *infuscata* in only 1, namely Family 5. The 8 former produced only *lycia* offspring; the latter only *infuscata*.

* The numbers suggest that, as regards this character, the parents were recessive and heterozygote respectively. If this be so, the female, belonging to the rarer form, was probably heterozygote, while *infuscata*, although dominant in relation to *lycia*, is recessive to the form with a fulvous bar.

The fact that 2 *lycia* parents should 8 times have produced offspring which were nothing but *lycia* strongly supports the view that this form is recessive. It is unfortunate that there was only a single family with *infuscata* parents, and that this one should have failed to afford evidence as to the dominance of the latter form.

Companies and Families with equality of infuscata *and* lycia.

The frequency with which there is exact or approximate equality between the two forms is striking. Omitting very small numbers, we notice conspicuous instances in Company 2, Families 3, 4, 6, 11, 13, & 20. It is to be observed that Family 3 is the only one of these that is not all-female.

The female parents of these groups, so far as they are known, are *infuscata* 3 times (Families 3, 6, & 11) and *lycia* twice (Families 4 & 13).

The Proportion of the all-female Companies and Families and of the Sexes in the mixed groups.

The two series bred from Wild Larvæ are omitted from these considerations because of the uncertainty which naturally attaches to them, although it must be remembered that there are good reasons for believing that the great majority of each set belonged to a single all-female family.

Three out of the 7 companies, and 16 out of the 21 families, are made up of all-female offspring. On the other hand, there are almost precisely 50 per cent. more males than females in the mixed sets. In 3 out of 4 companies with mixed sexes, the males are more numerous ; in the 4th (the very small Company 6) the numbers are equal (3 of each sex). The totals in these mixed companies are 68 males and 45 females, and in the 5 mixed families 82 males and 56 females. In this latter series there is also one exception, and a very marked one, namely, Family 3 with 11 males and 24 females. The totals, in all mixed companies and families, are 150 males and 101 females.

Relationship between the all-female and the mixed Families.

It is important to notice that the male parents may produce very definite hereditary effects upon their female offspring in the all-female families. Thus the Mendelian relationship between the forms of parents and offspring appears to be the same in all-female families as in those with mixed sexes.

It is quite clear that the all-female families bear no special relation to one of the local forms of *Acræa encedon* rather than another. They may be all *infuscata* or they may be all *lycia,* or approximately half *infuscata* and half *lycia.*

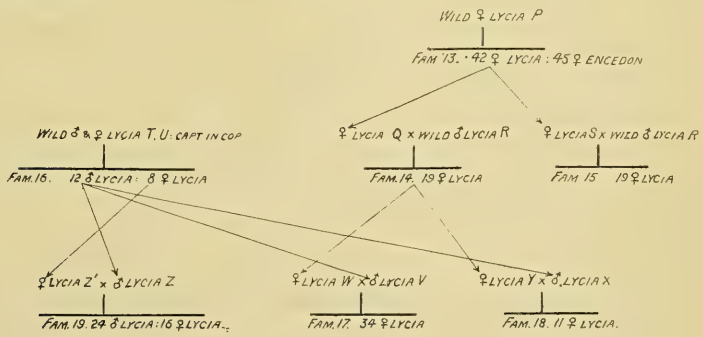
Considering the 19 all-female groups among the companies and families, 2 are all *infuscata* (the known parents of one being ♂ ♀ *infuscata*), 7 are all *lycia* (the known parents ♀ *lycia* twice, ♂ ♀ *lycia* five times), and 10 are mixed *infuscata* or *commixta* and *lycia* (the known parents ♀ *infuscata* twice, ♀ *commixta* once, and ♀ *lycia* four times).

Seven out of the 10 mixed groups are exactly or approximately half *infuscata* and half *lycia*. The remaining three are Company 5 with 6 *infuscata* to 16 *lycia*, Family 7 with 3 to 9, Family 8 with 7 to 21. It is rather curious that the proportions are here—exactly in the 2 families and approximately in Company 5—the Mendelian expectation if *lycia* were dominant and 2 heterozygotes had paired: an interpretation untenable for Family 7, of which the ♀ parent was not *lycia*. The probable explanation of these irregularities and that exhibited by Company 7 has been suggested on p. 396.

Among the 9 groups with mixed sexes, out of the 28 companies and families, 1 is all *infuscata* (parents unknown), 5 are all *lycia* (known parents ♂ ♀ *lycia* three times), and 3 are mixed *infuscata* and *lycia* (known parent ♀ *infuscata* once). Of these 3, Company 7 with 3 *infuscata* to 13 *lycia* is considered above, while the other two give approximate equality (Family 3) and probably rough equality (Company 4).

Probable existence of two strains of females, one producing all-female, and the other male and female families.

It will be observed in the Table on pp. 397–8 that Family 2 with mixed sexes was produced by a male and female *lycia* from Company 4 also made up of males and females. These facts favour the conclusion that the power of producing mixed sexes is hereditary. Confirmation is also provided by the offspring of Family 16, with mixed sexes, bred from a pair of *lycia* captured in the wild state. From two of these offspring sprang Family 19, also of mixed sexes. The relationship between Families 16 & 19 is shown in the following Table.



The existence of a strain producing nothing but females is supported by stronger evidence; for the breeding experiments extended over 3 generations, also set forth in the accompanying Table. In this we see that two males from the mixed Family 16, paired with females from the all-female Family 14, produced nothing but females in the resulting Families 17 and 18. Another male from Family 16, paired with a female from the same family, produced, as stated above, the mixed Family 19.

Although further evidence is desirable, the whole of Mr. Lamborn's experiments, so far as they bear on this subject, point in one direction. There are no grounds for the belief that parthenogenesis ever takes place in this species, but the determination whether the family is to be all-female or mixed rests solely with the female parent.

W. A. Lamborn's Breeding Experiments.

Wild Larvæ.—Two sets of wild larvæ collected on *Commelina* were bred, and it will be seen that there are indications of an all-female company in the later emergences of the first set and in all except the very latest emergences of the second.

Wild Larvæ 1.

These larvæ were collected in Googa Creek, about five miles north of Oni. Their whole life-history fell well within the wet season, which lasted from about April 25 to Nov. 15, 1910. The dates of emergence and some of the dates of pupation are shown in the following Table :—

Dates of Pupation. 1910.	Dates of Emergence. 1910.	*infuscata* and *commixta*.		*lycia*.	
		Male.	Female.	Male.	Female.
June 19.	June 26.		1		
„ 21.	„ 27.		1		
„ 20.	„ 27.		1		
„ 22.	„ 28.		1		
—	„ 30.	1			
„ 28.	July 4.	1			
—	„ 5.			1	
—	„ 6.				1
—	„ 7.	4	1	4	1
—	„ 8.				2
—	„ 9.		1		5
—	„ 10.				3
—	„ 11.		2		4
—	„ 12.				7
—	„ 13.				3
—	Totals	6	8	5	26

Three *commixta* are included in the series of *infuscata*, namely, 2 males emerging July 7 and 1 female emerging July 9. *Commixta* possesses a fulvous fore-wing subapical bar with a white hind wing, approaching that of the form *alcippina*. One other male of July 7 has the former of these characters only, and is thus transitional. Some *lycia* of this series also exhibited a slight suffusion of the fore wing with a fulvous tint.

Wild Larvæ 2.

The larvæ were collected on the bank of Oni River, about two miles north-west of Oni. Their whole life-history fell within the dry season, which lasted from about mid-Nov. 1910 to mid-March 1911. The dates of emergence are shown in the following table.

Dates of Emergence. 1910.	*infuscata* and *commixta*.		*lycia*.	
	Male.	Female.	Male.	Female.
Dec. 10		3		4
„ 11				3
„ 14		4		1
„ 15		8		6
„ 16		1		1
„ 17				1
„ 21		1		
„ 23			1	2
„ 24			2	
Totals		17	3	18

One female *commixta*, emerging Dec. 10, is included in the series of *infuscata*. The hind wing is whiter than in most other examples—so much so, indeed, that the specimen might, except for the fulvous fore-wing bar, be fairly classed under the form *alcippina*.

Companies :—The following 7 companies of larvæ were bred each from a batch of eggs laid on a single leaf of the food-plant *Commelina*, by the Oni River, about two miles north-west of Oni Camp. Great care was taken

to ensure that the larvæ of each company should be kept separate. The eggs themselves formed in each case a clump no larger than a threepenny-bit, and it may be assumed that each was laid by a single female. The dates at which some of the batches of ova were found were not preserved, but all of them fell into Dec. 1910 or Jan. 1911, and therefore well within the dry season, which extended from about mid-Nov. 1910 to mid-March 1911.

Company 1.

The eggs hatched Dec. 24, 1910. The 2 imagines which emerged on Jan. 21 pupated on Jan. 16. The other dates of pupation were not preserved.

The eggs produced both males and females, all of the form *lycia*, which emerged on the following dates :—

Dates of Emergence. 1911.	*lycia*.	
	Male.	Female.
Jan. 21	2	
„ 22	3	
„ 23	17	2
„ 24	1	
„ 25	18	8
„ 26	5	18
„ 28		3
„ 29		1
Totals	46	32

The individuals of this company are unusually dark, and in many specimens, principally males, the basal half of the fore wing is suffused with a faint fulvous tint varying in depth of shade. In the most extreme of these the fore wing may be called intermediate between *infuscata* and *lycia*. The two varieties in which the suffusion is most pronounced are males, emerging respectively on Jan. 23 and 25. In both of these the subapical bar of the fore wing is of a deeper shade than usual, so that these specimens approach the form *commixta*.

Company 2.

Eggs were found Dec. 24, and hatched Dec. 27.

The eggs produced 47 females, made up of nearly equal numbers of *infuscata* and *lycia*, which emerged on the following dates :—

Dates of Emergence. 1911.	Female *infuscata*.	Female *lycia*.
Jan. 30	4	4
„ 31	2	1
Feb. 1	2	3
„ 2	10	12
„ 3	2	2
„ 4	4	1
Totals	24	23

Company 3.

Eggs were found Jan. 1, and hatched Jan 3.

The eggs produced 35 females of the form *infuscata*, which emerged on the following dates :—

Dates of Emergence. 1911.	Female *infuscata*.
Feb. 1	2
„ 2	11
„ 3	9
„ 4	4
„ 5	3
„ 6	6
Total	35

Company 4.

Eggs were found Jan. 1, and hatched Jan. 3.

The eggs produced males and females of both *infuscata* and *lycia* :—

Dates of Emergence. 1911.	*infuscata.*		*lycia.*	
	Male.	Female.	Male.	Female.
Feb. 14	4		2	
„ 15	1		0	
„ 17		1	1[1]	1[2]
„ 18	1			
„ 19		1	1	
Totals	6	2	4	1

[1] Parent C, of Family 2 (p. 407).

[2] Parent D, of Family 2 (p. 407).

The individuals of this company were typical and uniform, with the single exception of the male parent, *lycia*, of Family 2, in which the basal half of the fore wing was slightly tinged with fulvous, a variation which appeared in many of its offspring.

Company 5.

The dates of capture and hatching were not kept.

The eggs produced 22 female offspring, of which 6 were *infuscata* and 16 *lycia* :—

Dates of Emergence. 1911.	Female *infuscata.*	Female *lycia.*
Feb. 21	1	
„ 22		1
„ 23		4
„ 24	5	11
Totals	6	16

Company 6.

The eggs hatched Jan. 28, 1911.

The eggs produced 3 males of the form *lycia*, which emerged on March 2 and 3 female *lycia* which emerged on March 2, 3, and 4, respectively.

Company 7.

The eggs hatched Feb. 1, 1911.

The eggs produced males and females both of *infuscata* and *lycia*:—

Dates of Emergence. 1911.	*infuscata.*		*lycia.*	
	Male.	Female.	Male.	Female.
March 11			4	
„ 13	1		3	
„ 16				1
„ 18				5
„ 19	1	1		
Totals	2	1	7	6

Families.—We now come to the series of 21 Families, in 19 of which either the female parent or both parents are known.

Family 1.

Parents A and B, both of the form *lycia,* were captured *in cop.* by the river at Idakun, 4 miles north-west of Oni, Dec. 1, 1910. The male A died Dec. 4. Eggs were laid on the back of a leaf, Dec. 2, and the female parent B was killed Dec. 4. The eggs had all hatched by Dec. 9.

The eggs produced 48 female offspring, all of the form *lycia,* which emerged at the dates shown in the following table. The dates of pupation are also included :—

Dates of Pupation. 1911.	Dates of Emergence. 1911.	Female *lycia.*
Jan. 1.	Jan. 7.	25
„ 2.	„ 8.	12
„ 3.	„ 9.	8
„ 4.	„ 10.	3
	Total	48

Family 2.

Parents C and D both of the form *lycia* (but it has already been pointed out on p. 406 that the male was slightly suffused with fulvous). Both parents belonged to Company 4, and both emerged and paired on Feb. 17. Eggs were laid Feb. 18.

The eggs produced both males and females of the form *lycia* :—

Dates of Emergence. 1911.	*lycia*.	
	Male.	Female.
March 27	5	1
„ 28	12	11
„ 29	2	1
Totals	19	13

The effect of the male parent was obvious in many specimens, especially in a male emerging March 27, which exhibits the same tendency in higher degree, and approaches *commixta*, like the 2 males of Company 1 (see p. 404). It must be remembered, however, that these two latter differ in other respects, belonging, as they do, to an exceptionally dark series.

Family 3.

Parent E. The female parent, of the form *infuscata*, was captured on the river-bank at Idakun. Eggs were laid Feb. 9–10 and hatched Feb. 13–14. The female parent died Feb. 10.

The eggs produced males and females both of *infuscata* and *lycia*, which emerged on the following dates :—

Dates of Emergence. 1911.	*infuscata*.		*lycia*.	
	Male.	Female.	Male.	Female.
March 18	1			
„ 20		2	1	
„ 21	1	3	1	1
„ 22	1	1	2	
„ 23	1	3	2	1
„ 24				4
„ 25				4
„ 26		1		
„ 27		1		2
„ 29	1			1
Totals	5	11	6	13

Family 4.

Parent F. The female parent, of the form *lycia*, was captured in Oni clearing near the lagoon. Two batches of eggs were laid with a day's interval. The first batch began to hatch on Sept. 6, and pupation commenced on Oct. 5.

The eggs of the first batch produced 51 all-female offspring, of which 29 were *infuscata* and 22 *lycia*. One *infuscata* emerged Oct. 12 and the remaining butterflies from this day onwards, but precise dates were not recorded.

The eggs of the second batch hatched Sept. 7–8, and pupation took place from Oct. 5. Of the 18 resulting females, 4 were *infuscata* and 14 *lycia*. These emerged on the following dates :—

Dates of Emergence. 1911.	Female *infuscata*.	Female *lycia*.
Oct. 11.....	2	2
„ 12.....	1	4
„ 13.....		1
From „ 11.....	1	7
Totals	4	14

Family 5.

Parents G and H, both of the form *infuscata*, were captured *in cop.* in Oni Clearing by the lagoon, Sept. 15, 1911. The male G is a typical West African *infuscata*, although the subapical fore-wing bar is paler than usual, perhaps as a result of wear. In the female, however, the same marking is of a fulvous tint, as in *commixta* and *daira*. Eggs were laid Sept. 18 and hatched Sept. 26. The female parent died Sept. 20. No dates of emergence were kept, but the whole cycle fell well within the wet season, which lasted from about mid-March to Dec. 8, 1911.

The eggs produced 28 female offspring, all of the form *infuscata*—15 with the white subapical bar of the ordinary female *encedon*, 13 with the fulvous bar of the female parent. In two of this latter set, the hind wings are partially white, so that the specimens closely approach the form *commixta*.

It should furthermore be noted that some of the 13 specimens were much worn, but the scales still remaining left no doubt that the bar had been fulvous and not white.

Family 6.

Parent I. The female parent, of the *infuscata* form, was captured in Oni Clearing, April 27, 1912. Eggs were laid between April 30 and May 1, and the butterfly died May 2.

The eggs produced 42 female offspring, which emerged on the following dates. A single male *lycia* may have been accidentally introduced :—

Dates of Emergence. 1912.	Female *infuscata*.	Female *lycia*.
May 29	1	2
„ 30	1	1
„ 31	2	5
Unnoted.....	17	13[1]
Totals	21	21

[1] In addition to the above, a single ♂ *lycia* was found in this category. It is excluded from the table because it seems probable that its appearance was due to accident.

Family 7.

Parent J. The female parent was captured in Oni Clearing, May 5, 1912. This female is much worn, but there is no doubt that it is of the form *commixta*. The pale fulvous fore-wing bar is evident in the specimen. Eggs were laid May 6, and the butterfly died May 8.

The eggs produced 12 female offspring, of which 3 were *commixta* and 9 *lycia*. The date of emergence, June 6, was only noted for a single *lycia*.

Family 8.

Parent K. The female parent, of the form *lycia*, was captured in Oni Clearing, May 7, 1912. Eggs were laid May 7, and the butterfly died May 8.

The eggs produced 28 female offspring, of which 7 were *infuscata* and 21 *lycia*. The dates of emergence were not noted.

Family 9.

Parent L. The female parent, of the form *lycia*, was captured in Oni Clearing on May 8, 1912. Eggs were laid May 9, and the butterfly died May 11.

The eggs produced on June 13, 2 female offspring, of which 1 was *infuscata* and 1 *lycia*. The latter is noticeably darker than its parent.

Family 10.

Parent M. The female parent, a rather dark *lycia*, was captured in Oni Clearing on June 1, 1912. Eggs were laid June 2, and the butterfly died June 4.

The eggs produced 12 female offspring of the form *lycia*, of which 5 emerged July 14 and 7 July 15.

The offspring are uniformly dark like the female parent.

Family 11.

Parent N. The female parent, of the form *infuscata*, was captured in Oni Clearing, June 1, 1912. Eggs were laid June 2, and the butterfly died June 5.

The eggs produced 26 female offspring, of which 12 were *infuscata* and 14 *lycia*. Emergence took place on the following dates :—July 12, *infuscata* 11, *lycia* 12 ; July 17, *infuscata* 1, *lycia* 1 ; July 18, *lycia* 1.

Family 12.

Parent O. The female parent, of the form *lycia*, was captured in Oni Clearing on June 8, 1912. Eggs were laid on June 8–9, and the butterfly died June 10.

The eggs produced 41 female offspring, all of the form *lycia*, which emerged as follows :—July 13, eighteen ; July 17, six ; July 18, fourteen : July 19, three.

Family 13.

Parent P. The female parent, of the form *lycia*, was captured at the edge of the lagoon near Oni Clearing on April 19, 1912. The larvæ produced by the first batch of ova, laid April 21, were reared separately from those of the second batch, laid April 22. The parent died April 24.

The ova of the first batch hatched April 27, and produced 61 female offspring of both forms which emerged on the following dates :—

Dates of Emergence. 1912.	Female *infuscata*.	Female *lycia*.
May 24	2	2
„ 25	15	7
„ 26	3	9
„ 28	12	2
„ 29	2	7
Totals	34	27

The ova of the second batch hatched April 28, and produced 26 female offspring of both forms which emerged on the following dates :—

Dates of Emergence. 1912.	Female *infuscata*.	Female *lycia*.
May 22	0	2[1]
„ 25	1	3
„ 26	4	9
„ 27	2	0
„ 28	4	1
Totals	11	15

[1] These 2 *lycia* females became respectively the female parents S and Q, see p. 413.

Both *infuscata* and *lycia* were typical, but the latter varied in the extent of the black pigmentation of the fore wing.

Family 14.

Parents R, Q. The male parent R, of the form *lycia*, captured in Oni Clearing, May 24, 1912, paired May 24 with the female parent Q, of the

form *lycia*, one of the offspring emerging May 22 of the all-female family of parent P. (The male parent R subsequently paired with S.) Eggs were laid May 25 and 26 and the female parent died May 27.

The eggs produced 19 female offspring, all of the form *lycia*, which emerged on the following dates :—June 29, one ; June 30, sixteen ; July 1, two.

Two of the females which emerged on June 30 became respectively the female parents W and Y (see p. 414).

Family 15.

Parents R, S. The male parent R, of the form *lycia*, captured in Oni Clearing, May 24, 1912, paired May 26 with the female parent S, of the form *lycia*, one of the offspring emerging May 22 of the all-female family of parent P. (The male parent R had previously paired with Q.) Eggs were laid May 27–29, and the female parent died June 1.

The eggs produced 19 female offspring, all of the form *lycia*, which emerged on the following dates :—

Dates of Emergence 1912.	Female *lycia*.
July 1	3
„ 2	4
„ 4	6
„ 7	2
„ 9	4
Total	19

Family 16.

Parents T, U, both of the form *lycia*, were captured *in cop.* in Oni Clearing, May 24. Eggs were laid in 3 batches May 25–27, and the female parent U died May 29.

The eggs produced both males and females, all of the form *lycia*, which emerged on the following dates :—

Dates of Emergence 1912.	*lycia.*	
	Male.	Female.
June 28	1 [1]	0
„ 29	4[2]	3[3]
„ 30	4	1
July 1	2	1
„ 2	0	1
„ 3	0	1
„ 8	1	1
Totals	12	8

[1] This male became parent V, see below.
[2] Two of these males became respectively parents X and Z, see pp. 414, 415.
[3] One of these females became parent Z′, see p. 415.

The series exhibited much variation in the extent of the black pigmentation of the fore-wing and the hind-wing border.

Family 17.

Parents V, W. The male parent V, of the form *lycia*, was one of the offspring, emerging June 28, of the mixed family of parents T, U. The female parent W, of the form *lycia*, was one of the offspring, emerging June 30, of the all-female family of parents R, Q. Pairing took place on June 30. Eggs were laid June 30 and July 1, and the female parent died July 4.

The eggs produced 34 female offspring, all of the form *lycia*. The dates of emergence were not noted.

The family exhibits variation in pigmentation, but to a less extent than that of Family 16.

Family 18.

Parents X, Y. The male parent X, of the form *lycia*, was one of the offspring, emerging June 29, of the mixed family of parents T, U. The female parent Y, of the form *lycia*, was one of the offspring, emerging June 30, of the all-female family of parents R, Q. Pairing took place on

June 30. Eggs were laid in 4 small batches July 2–4, and the female parent died July 6.

The eggs produced 11 female offspring, all of the form *lycia*. The dates of emergence were not noted.

The variation in pigmentation is about the same as that of Family 17.

Family 19.

Parents Z, Z′. The male parent Z, of the form *lycia*, was one of the offspring, emerging June 29, of the mixed family of parents T, U. The female parent Z′, of the form *lycia*, was also one of the offspring, emerging June 29, of the same parents T, U. Pairing took place on June 30. Eggs were laid July 1–2, and the female parent died July 5.

The eggs produced both males and females, all of the form *lycia*, which emerged on the following dates :—

Dates of Emergence. 1912.	*lycia*.	
	Male.	Female.
Aug. 9	10	2
„ 10	2	2
„ 12	4	1
„ 13	4	7
„ 14	4	4
Totals	24	16

The variation in pigmentation is rather greater than in Families 17 and 18.

Family 20.

The parents of this and the next family were not found in Mr. Lamborn's material, and there is no note as to whether they were *infuscata* or *lycia*. A box of specimens appears to have gone astray, and it is probable that these two parents were included in it.

The family, all of which bore the same number ("834"), consists of females of *infuscata* and *lycia* in approximately equal numbers, which emerged on the following dates :—

Dates of Emergence, 1912.	Female *infuscata*.	Female *lycia*.
July 4	2	7
„ 5	5	11
„ 6	7	10
„ 8	4	0
„ 11	0	2
„ 12	17	6
Totals	35	36

Family 21.

Parent unknown. The family, all of which bore the same number ("846"), consists of males and females of *infuscata*, which emerged on the following dates :—

Dates of Emergence, 1912.	*infuscata*.	
	Male.	Female.
July 17	5	3
„ 18	9	0
„ 19	0	1
„ 20	2	1
Totals.....	16	5

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Some Terrestrial Isopoda from New Zealand and Tasmania, with Description of a New Genus.

By Charles Chilton, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., Professor of Biology, Canterbury College, New Zealand.

(Plates 36 & 37.)

[Read 7th May, 1914.]

In this paper I establish a new genus for two New Zealand species of terrestrial Isopoda. Both have been already described and provisionally placed under the genus *Haplophthalmus*, to which the new genus seems closely allied, but additional specimens recently obtained have permitted a fuller investigation of them than was previously possible.

I also include descriptions of a new species of *Haplophthalmus* from Tasmania, and of a new species of *Cubaris* from Auckland, New Zealand. In both cases I have only a single specimen, and I have waited for several years in the hope of obtaining others, but as no further specimens have been obtained, and as the species seem to be well characterized and likely to be easily recognized, I now venture to describe them.

Family Trichoniscidæ.

In 1901 I described a new terrestrial Isopod from Greymouth, New Zealand, under the name *Haplophthalmus helmsii*, though I pointed out at the time that it differed from that genus as described by Sars (1898, p. 166) in having the first *three* (instead of *two*) segments of the pleon small and without lateral expansions. In 1909 I described from Campbell Island, lying to the south of New Zealand, another species, *H. australis*, which also differed in this respect from the generic characters, and I stated that a new genus would probably have to be established for these two species, though, as the material at my disposal was small, I postponed doing so at the time.

I have recently received from Mr. T. Hall several specimens collected at Mt. Algidus, Rakaia Gorge, Canterbury, of an Isopod which at first appeared distinct from both of those mentioned above, though agreeing with them in the character referred to. I had commenced to describe this as a new species and had drawn up a diagnosis for a new genus to include these forms. Further investigation, however, has shown that these specimens are not really distinct from *Haplophthalmus helmsii*, and that the characters that appeared to distinguish them are due to the greater development of the dorsal tubercles or crests in the larger and older specimens; *H. helmsii* was

described from a single small immature specimen. I therefore give a fuller description both of this and of *H. australis*, and place them under a new genus *Notoniscus*. This may be described as follows :—

Notoniscus, nov. gen.

Generic characters :—Body oblong, central portion moderately convex, dorsal surface sculptured and bearing ridges or tubercles. Head with the front triangularly produced, lateral lobes directed downwards, rather small, with extremity subacute. Side plates of body lamellarly expanded, projecting almost horizontally, discontiguous. Pleon not abruptly contracted, epimeral plates of the three anterior segments very small or absent, those of the 4th and 5th segments well developed, lamellar; last segment with truncate posterior margin. Eyes small, but with more than one visual element; antennules, antennæ, and mouth-parts as in *Trichoniscus*. Legs rather short, not increasing much in length posteriorly; dactylar seta as in *Trichoniscus*. Uropoda with rami rather widely separated, subequal.

This genus seems near to *Haplophthalmus*, but differs in the character of the eyes and in the fact that the first *three* segments of the pleon have the epimeral plates very small or absent.

The genus so far as at present known is confined to New Zealand and the adjacent islands and contains two species which may be distinguished as follows :—

1. Body oblong-oval, with well marked ridges or tubercles . *N. helmsii.*
2. Body oval, with indistinct tubercles *N. australis.*

Notoniscus helmsii (*Chilton*). (Pl. 36. figs 1–8.)

Haplophthalmus helmsii, Chilton, 1901, p. 119, pl. 12. fig. 3.
„ „ Chilton, 1910, p. 288.

Specific characters :—Body oblong-oval, about half as broad as long, moderately convex, central portion raised somewhat abruptly above the epimeral portions, which are well developed, nearly horizontal and widely separated. Head with the dorsal surface bearing posteriorly two prominent tubercles or short ridges projecting upwards and a little forwards, anterior to these are smaller tubercles; the front triangularly produced and somewhat rounded; lateral lobes rather small with extremities subacute, projecting downwards below the raised central portion of the head. Dorsal surface of the body sculptured, each segment with a short ridge or tubercle situated laterally near the outer border of central portion and running obliquely backwards and outwards; on the three posterior segments the tubercles gradually become more distinct and pointed, projecting backwards a little

over the succeeding segments; on the four anterior segments there is a smaller and usually less-marked ridge or tubercle internal to the one already described and parallel to it; on all the segments are slight indications of other tubercles or sculpturings. Pleon not much narrower than the peræon, surface smooth; first two segments small and without epimeral plates, third segment with very small epimeral plates, the fourth and fifth segments with epimeral plates largely developed, lamellar, the last epimeral plates reaching more than half way to the end of the terminal segment; last segment short, broader than long, truncate at the apex.

Eyes small, situated on a slightly rounded prominence above the lateral lobes, containing three ocelli. Antennæ short, hardly one-fourth the length of the body; fourth joint of peduncle slightly expanded on outer side, shorter than the fifth which is narrowed at the base, all with appressed scales and short setæ, one or two longer setæ on the fifth joint; flagellum as long as the fourth joint, containing 3 or 4 subequal joints and ending in a pencil of long setæ. Legs all short and rather stout, not visible in dorsal view, apparently not showing secondary sexual characters in the male. Uropoda short, base large and broad, its outer margin expanded and strongly convex; inner ramus slightly longer and more slender than the outer, arising anteriorly to it but reaching as far backwards.

Length of largest specimen, 8 mm.

Colour. General surface light brown with markings of darker brown.

Habitat. Greymouth, one specimen (*R. Helms*); Mt. Algidus, Rakaia Gorge, several specimens (*T. Hall*).

This species was originally described from a single small specimen found at Greymouth by Mr. R. Helms. The tubercles or ridges on its surface are much less marked than in the larger specimens more recently collected by Mr. T. Hall at Mt. Algidus. It is difficult to represent accurately the appearance of the dorsal surface of an animal such as this, and in my original figure (1901, pl. 12. fig. 3) the ridges are less conspicuous than they should be even for the type-specimen which is there represented; on the other hand the figure which I now give, drawn for me by Mr. B. Broadhead from a larger and more adult specimen, perhaps errs in the other direction of making the ridges or tubercles appear somewhat too prominent. Smaller specimens from Mt. Algidus closely resemble the type-specimen, and I have no doubt that we are dealing with one species only, in which the ridges on the dorsal surfaces become more prominent in the older specimens, and, particularly in the posterior segments, project from the general surface as well-marked, somewhat pointed tubercles.

General description:—The antennæ (fig. 2) have already been sufficiently described, the expansion of the fourth segment of the peduncle is less marked in the older specimens than it was in the type-specimen; in the type the

flagellum consists of three joints, in other specimens it seems usually to contain four.

The mouth-parts show on the whole a pretty close resemblance to those found in species of *Trichoniscus* and are almost the same as those of the next species which are described in greater detail, it will therefore be only necessary here to mention one point of difference; in the maxillipeds (figs. 3 & 4) the epipod is widened at the base and narrows distally, and thus looks somewhat different in shape from that of *N. australis*.

The legs (fig. 5) are all short and of about equal length; they are all somewhat stout, the basal joint is rather broad and has a slight depression on its outer surface to receive the more distal joints when folded back upon it; the carpus is broad and bears few setæ, one towards the distal end being much longer than the others; the propod is much narrower than the carpus and tapers towards its distal end, the outer surface is thickly fringed, especially on the distal half, with fine rather long setæ, while the inner margin bears only one or two stout setæ situated about the middle of the margin; the dactyl is long and slender and bears numerous strongly curved setæ near the base, from which also arises the long dactylar seta which projects a little beyond the end of the dactyl itself, and is of the same general character as in species of *Trichoniscus*.

The pleopoda are also of the same general type as in *Trichoniscus* and the first and second pairs are specially modified in the male. In the first pleopod (fig. 6) the outer branch forms a delicate plate with curved outer margin and minute crenulations at the distal end, the inner plate forms a narrow stout process bearing at the end an extremely long, sharp style; the median organ is broad, expanding towards its distal end, which is deeply emarginate with a small nodule in the centre of the emargination, the basal part seems somewhat strongly chitinized but the extremity appears thin and membranous with a wrinkled appearance. The second pleopoda (fig. 7) have the outer plate lamellar and of the usual shape, the inner branch being modified into a strong biarticulate, cylindrical copulatory organ of nearly the same width throughout its length except towards the end which narrows abruptly; along its inner side there runs a narrow groove which curves upwards towards the end.

The 3rd, 4th, and 5th pleopoda are similar to those of *N. australis* and consist of an outer opercular plate and a smaller inner branchial plate, the branchial plate apparently becoming smaller in proportion to the opercular one in the more posterior pleopoda.

The uropoda (fig. 8) have the basal joint expanded outwardly with strongly convex margin, the two rami are somewhat widely separated, the inner one being slightly the longer and more slender.

In the female I have not succeeded in finding the first pleopoda, they are

probably small as in *Haplophthalmus*. The second pleopod has the inner branch slender, much longer than the outer, tapering, and with the distal portion marked with fine transverse lines apparently due to transverse rows of very minute setæ. The third, fourth, and fifth pleopoda are similar to those of the male.

NOTONISCUS AUSTRALIS (*Chilton*). (Pl. 36. figs. 9–16, and Pl. 37. figs. 17–22.)

Haplophthalmus australis, Chilton, 1909, p. 662.
„ „ Chilton, 1910, p. 288.

Specific description:—Body oval, greatest breadth in the 3rd and 4th segments of peræon, where it is about half the total length; central portion of body moderately convex; epimeral plates large, projecting horizontally, rather widely separated. Head with two small rounded tubercles about the centre and an indistinct obliquely longitudinal ridge on each side, the front triangularly rounded; lateral lobes small, depressed, with extremities subacute. Dorsal surface of peræon sculptured, each segment with a number of rounded or irregular tubercles arranged so as to form a fairly well-marked median ridge and one or two less distinct lateral ridges; the tubercles becoming more indistinct on the posterior segments. Surface of pleon smooth, first three segments short, first two quite without epimeral expansion, the third with very small epimera, fourth and fifth with moderately expanded epimera; terminal segment broad with straight posterior margin.

Eyes with three ocelli. Antennæ rather slender, the 4th joint of peduncle not expanded, slightly longer than the two preceding combined, and rather shorter than the 5th; flagellum about as long as the fifth joint, containing four or five subequal joints, the last tipped with a pencil of long setæ; whole antenna covered with fine short setæ, a stouter seta at the end of each of segments 2, 3, 4, and 5 of peduncle. Legs short, subequal, not visible in dorsal view; no secondary sexual characters observed. Uropoda with the base not greatly expanded, its outer margin straight or only slightly convex; rami subequal, the inner one slightly more slender than the outer, both covered with fine setæ and bearing long setæ at the extremities.

Length 6 mm.

Colour. Light brown.

Habitat. Campbell Island, on decaying wood and at roots of plants (*C. Chilton* and Messrs. *Chambers* and *Des Barres*).

This species, though closely allied to the preceding, appears to be distinguished from it by the more oval shape of the body, the less marked ridges or sculpturings of the dorsal surface, the more slender antennæ, and

less well-marked expansions of the epimera of the third and fourth pleon segments and of the base of the uropoda.

Campbell Island lies about 400 miles to the south-west of New Zealand, and the existence on it of this terrestrial Isopod so nearly allied to the species on the mainland is additional evidence that the island was formerly directly connected with New Zealand. No species of *Notoniscus* has yet been recorded from the Auckland Islands which lie between Campbell Island and the mainland, but probably *N. australis* or a closely allied species will be found to occur there.

General description :—As the mouth-parts and other organs of this species have been investigated more fully than those of *N. helmsii*, it will be convenient to give a more detailed description than was done for that species.

The *antennules* (Pl. 36. fig. 10) are small, consisting of the usual three joints, the first of which is much the largest, it is more than twice as long as the second and a little longer than the third, which is much narrower than the second and bears at the end one or two minute spinules.

The *antennæ* (fig. 11) hardly require any description beyond that already given.

The *upper lip* (fig. 12) is of the usual shape, quadrangular, narrowing somewhat distally and with the free margin convex and fringed in the centre with very minute setæ.

In the *mandibles* the right and left pairs differ in the character of the accessory appendage. The right mandible (fig. 14) has the main cutting-edge divided into three prominent teeth; the accessory appendage is somewhat cylindrical, curved, and has the apex rounded and bordered with a circular row of stout setæ closely set together, at its base arises a single long fringed seta; the molar tubercle is of the usual form. In the left mandible (fig. 13) the main cutting-edge contains three or four strongly chitinized teeth; the accessory appendage is similar in appearance to the main cutting-edge and it is divided into three similar teeth; at its base and between it and the molar tubercle arise two long fringed setæ.

The *lower lip* is deeply cleft, each lateral lobe with outer margin strongly convex and fringed with minute setæ arranged in small tufts or very short transverse rows; the whole of the extremity and the inner margin of each lobe is fringed with numerous fine, fairly long setæ. There is apparently a median portion to the lower lip somewhat similar to that described by Racovitza (1907 and 1908) for some species of *Trichoniscus* and allied genera, but it is very delicate and I have not made it out with certainty in the single specimen that I was able to dissect.

The *first maxilla* (fig. 17) has the two lobes of the usual form and of about equal length, the outer being as usual much the broader; nearly the whole of its outer margin is fringed with short transverse rows of small setæ, its

extremity bears about eight or nine strongly curved teeth of the usual character and there are a few fine setæ on the distal portion of the inner margin; the inner lobe bears at the end the usual three plumose setæ of unequal length, the most distal one being the smallest, a few minute setæ are found near its base at the apex of the lobe.

The *second maxilla* (fig. 16) has a few long slender setæ at the base of the inner margin; the apex is indistinctly divided into the usual two lobes, the outer one being much the smaller, the whole of the inner lobe is thickly covered with rather stout short curved setæ; more delicate setæ are present on the outer lobe and on the distal part of the outer margin of the maxilla.

The *maxillipeds* (fig. 18) are of the usual form; the epipod is about half as long as the broadly expanded second joint, it is rounded at the extremity, which bears a few very delicate setæ, and it is slightly narrower near the base where both margins are fringed with fine setæ; the broadly expanded second joint is about twice as long as broad, the very convex outer margin is regularly fringed in its distal half by long delicate setæ, and the whole of the inner margin is fringed with slightly stouter setæ. The palp portion is formed of a single piece with setæ of different kinds arranged so as to indicate faintly the separate joints which it represents; at the apex of the masticatory appendix or inner lobe is a small conical portion bearing three or four circlets of minute setæ.

The *legs* are slightly longer and more slender than those of *N. helmsii* and of the same general character, they do not increase in length posteriorly, and I have not observed any secondary sexual characters in connection with them. Plate 37. fig. 19 represents a leg of the first pair; the setæ on the merus and carpus are more numerous than those in the corresponding positions in *N. helmsii*, and on the inner margin of the propod are three fairly stout setæ placed at regular intervals along its length; the propod is slender, narrowing considerably towards the extremity, and on its lateral surface about the middle there is a small area thickly covered with short minute setæ; this patch of setæ, however, does not appear to be present in the other legs.

In the *pleopoda* I have not made out the first pair in the female, they are probably small as in species of *Haplophthalmus*; the second pair has the form represented in fig. 20, having the inner branch long, narrow, tapering to the end, which is marked with fine transverse lines which appear to be formed of minute transverse rows of setæ. I had originally described this as the pleopod of a male specimen; it corresponds, however, to the second pleopoda of the females of some species of *Trichoniscus* and allied genera. I have only a small number of specimens of this species and have not found a male among them. The third (fig. 21), fourth, and fifth pleopoda have the same general character as in *N. helmsii*.

The *uropoda* (fig. 22) are rather more slender and elongated than in *N. helmsii* and the basal portion is not so expanded as in that species, its outer margin being almost straight; the two rami are of about equal length, the inner one, however, being slightly more slender.

HAPLOPHTHALMUS TASMANICUS, sp. nov. (Pl. 37. fig. 23.)

Specific characters:—Body oblong oval, rather convex; epimera of segments of peræon not much produced and projecting more or less downwards, nearly contiguous; dorsal surface of each segment of the peræon with about six tubercles or ridges arranged so that they form longitudinal ridges along the peræon, the middle pair lying near the median line and the others more laterally; the outermost ridges less distinct than the others. Surface of pleon nearly smooth, first two segments short and without lateral expansions; the third, fourth, and fifth with moderately large expansions.

The head with surface irregularly tuberculate and roughened, produced in front into a bilobed tubercle. Lateral lobes small and not projecting far from head.

Eyes with three ocelli.

Antennæ short; flagellum as long as last joint of peduncle, indistinctly 3- or 4-jointed.

Legs all short, not seen in dorsal view. Uropoda short, the two branches subequal.

Length 5 mm. Width 2 mm.

Colour. Dark brown.

Habitat. Under rotten logs, Fern Tree Gully, Hobart, Tasmania; collected by Dr. Dendy in 1889. I have only a single specimen.

In the sculpturing of the dorsal surface this species appears to be near to *H. mengii* (Zaddach), but in that species there is a pair of prominent ridges on the third segment of the pleon and the longitudinal ribs on the peræon seem rather better marked.

As I have only the one specimen of this species I have not dissected it to examine the mouth-parts; the legs appear to be all of about equal length and of the usual character.

I have placed the species under *Haplophthalmus* as it seems to come near to that genus; it differs, however, from the description given by Sars in having the eyes not simple but composed of three ocelli, and the segments of the peræon are not discontiguous laterally.

Family Oniscidæ.

Cubaris suteri, sp. nov. (Pl. 37. figs. 24–28.)

Specific description:—Oblong oval, breadth rather more than half the length; epimeral portions fairly well developed especially in the first segment of peræon; central portion of each segment very convex, sculptured, and produced into transverse crests. Head with the anterior margin turned upwards into a well-defined ridge which is without a notch in the centre, behind this is a slight depression followed by an irregular transverse ridge in front of the hind margin. First segment of peræon with epimeral portion large, projecting almost horizontally, produced anteriorly almost as far as the antero-lateral angle of the head; each segment of peræon with its posterior margin produced dorsally upwards into a vertical ridge extending transversely throughout the whole of the central portion; this ridge becomes better marked in the more posterior segments until in the seventh segment it forms a distinct well-marked flange on the central portion of the segment with its upper margin depressed in the centre and its lateral angles rounded; in front of the posterior ridge of each segment there is a number of small tubercles on each side of the median line; on the more posterior segments these are better marked and end more acutely; on the anterior segments they are more rounded. The inferior margin of first segment of peræon (fig. 26) is deeply cleft posteriorly for reception of the succeeding segment, and the inferior margin of the second segment bears a well-marked tubercle on its inner surface enclosing a notch for the reception of the succeeding segment. Pleon (fig. 25) almost smooth, epimeral portions well developed, projecting almost horizontally; last segment of usual shape, its posterior margin slightly concave.

Eyes of moderate size, composed of numerous facets. Antennæ (fig. 27) normal, minutely setose; flagellum much shorter than terminal joint of peduncle, its first joint about one-fourth the length of the second. External ramus of the uropoda very small, inserted in a small notch on the inner margin of the expanded base, not visible from below; internal ramus very small and short forming a small knob, hardly projecting from the base (see fig. 28).

Length. About 8 mm.

Colour. Light brown, nearly the whole of the body being covered with marblings of a darker brown.

Habitat. Henderson, Auckland, a single specimen (*H. Suter*).

This species, of which I have only the single specimen, can readily be distinguished from all other New Zealand species by the sculpturings on the dorsal surface. The only other one known with sculpturings at all similar

is *Cubaris hamiltoni* (Chilton) (1901, p. 148) *, but in that species the ridges and flanges are far more numerous and are differently arranged.

The fact that both these specimens are known from single specimens only shows how incomplete our knowledge of the terrestrial Isopoda of New Zealand still is. Probably a careful survey, especially in the forests of the North Island, would bring to light several other interesting species.

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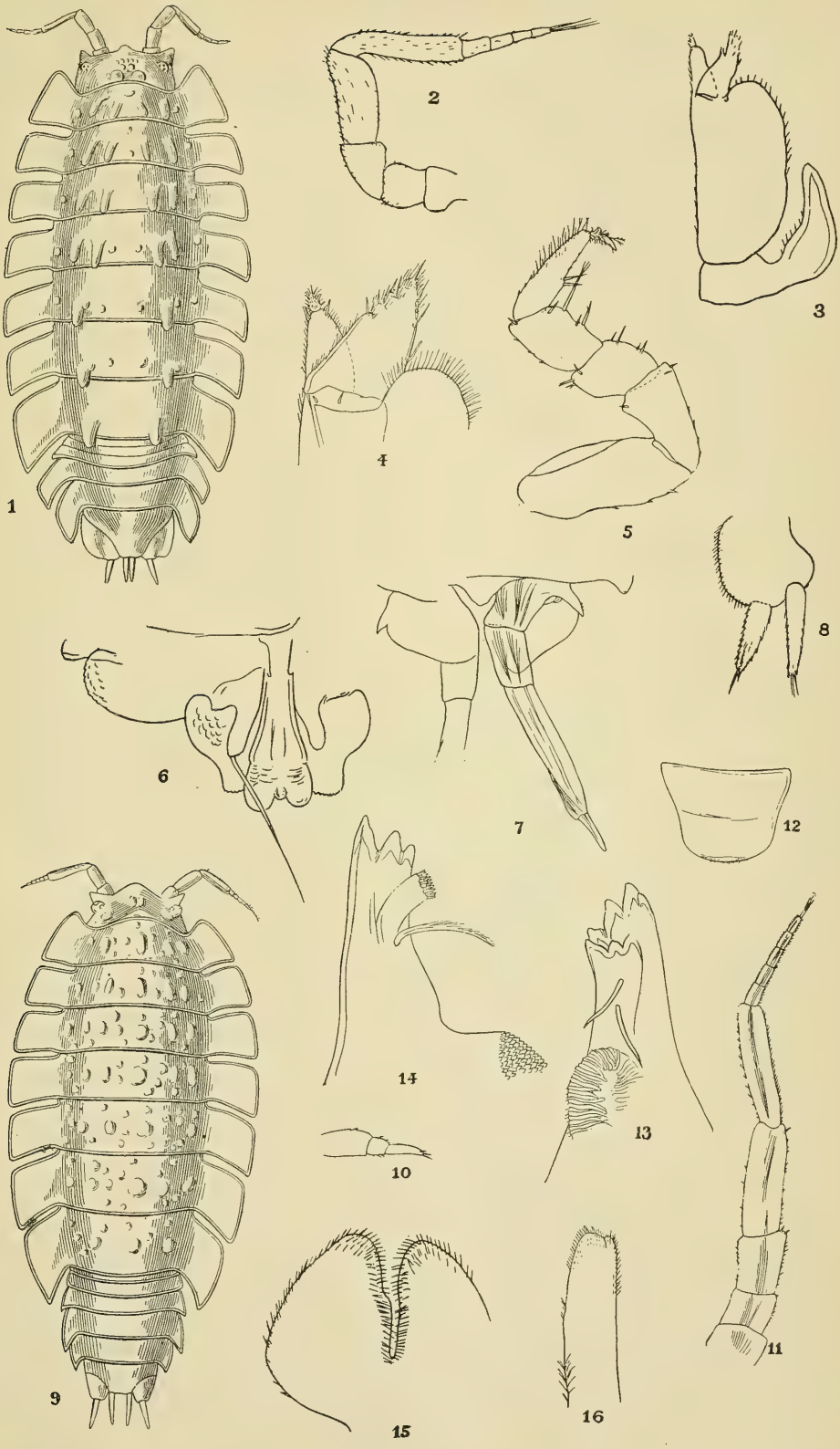
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EXPLANATION OF THE PLATES.

Plate 36.

Fig. 1. *Notoniscus helmsii* (Chilton); dorsal view, × about 10.
2. „ „ antenna.
3. „ „ maxilliped.
4. „ „ extremity of maxilliped, more highly magnified.
5. „ „ first leg.
6. „ „ first pleopod of male.
7. „ „ second pleopod of male.
8. „ „ uropod.
9. *Notoniscus australis* (Chilton); dorsal view, × about 12.
10. „ „ antennule.
11. „ „ antenna.
12. „ „ upper lip.
13. „ „ left mandible.
14. „ „ right mandible.
15. „ „ lower lip.
16. „ „ second maxilla.

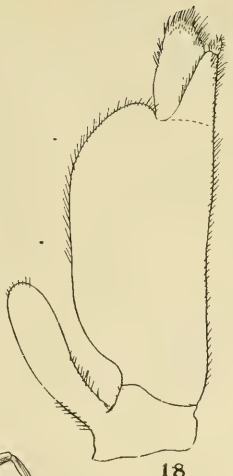
* See also G. M. Thomson (1893, p. 225).

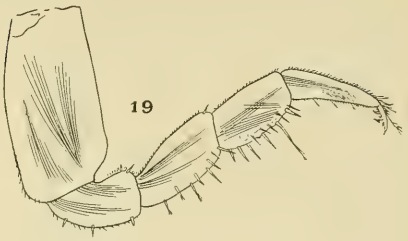


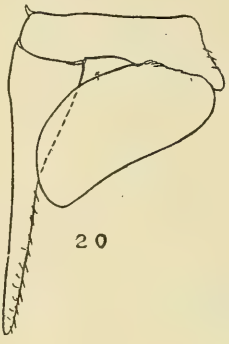
B. Broadhead & C.C. del. Grout sc. & imp.

TERRESTRIAL ISOPODA.

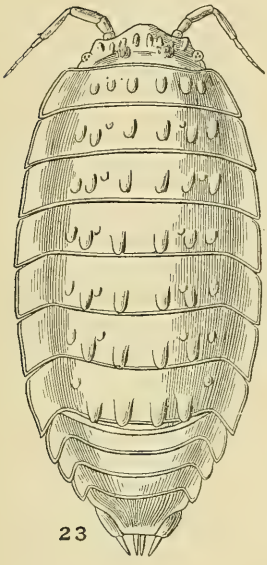

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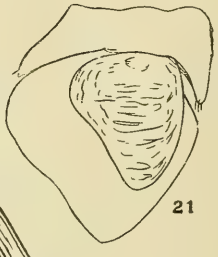

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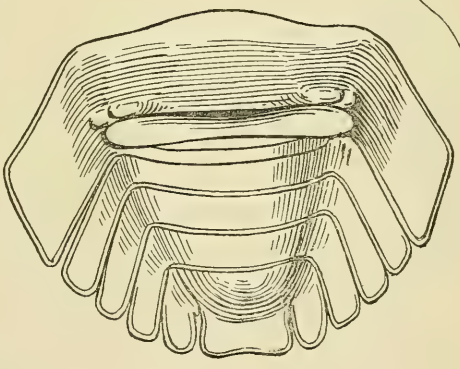

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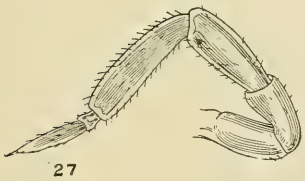

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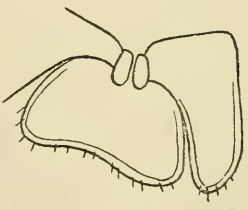

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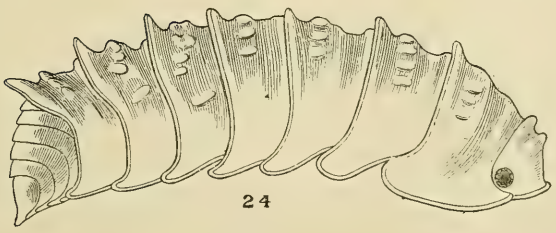

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B. Broadhead & C.C. del. Grout sc. & imp.

TERRESTRIAL ISOPODA.

Plate 37.

Fig. 17. *Notoniscus australis* (Chilton); first maxilla.
18. „ „ maxilliped.
19. „ „ first leg.
20. „ „ second pleopod of female.
21. „ „ third pleopod of female.
22. „ „ uropod.
23. *Haplophthalmus tasmanicus*, sp. nov., dorsal view, × about 18.
24. *Cubaris suteri*, sp. nov.: side view, × about 10.
25. „ „ dorsal view of pleon, more highly magnified.
26. „ „ segments 1 and 2 of peræon seen from below.
27. „ „ antenna.
28. „ „ uropod and telson.

The Genus *Lernæodiscus* (F. Müller, 1862).

By Geoffrey W. Smith, M.A., F.L.S.

(Plate 38.)

[Read 7th May, 1914.]

The genus *Lernæodiscus* was created by F. Müller in 1862 (1) for a Rhizocephalous parasite found by him on a *Porcellana* from Brazil. He did not describe the internal anatomy of the parasite, and nothing more was known about it until I gave an account of the genus in my Monograph of the Rhizocephala in 1906 (2), based on some specimens found on *Galathea dispersa* at Naples, on *G. intermedia* from Norway, and on *G. strigosa* from Naples. Since the appearance of this work two French authors have added to our knowledge of the genus, Dr. Max Kollmann (3 & 4) and Dr. Guérin-Ganivet (5). These authors have accepted the account I gave of the anatomy, but Dr. Kollmann disagrees with my interpretation of the orientation of the parasite and offers a different one.

The re-examination of the question which is here undertaken is due to Professor W. A. Herdman, who found a specimen of Rhizocephala upon a *Munida bamffica* from the Shetlands and sent it to me for identification. I had previously seen two Rhizocephalous parasites on *Munida*, and described them as a new genus *Triangulus* in my monograph (2, p. 115) ; but since I was only able to study these two specimens (which were not very well preserved) macroscopically, I was in considerable doubt as to the correctness of my diagnosis. I was anxious therefore to study Professor Herdman's specimen by means of serial sections, which he very kindly permitted me to do, and the result of this examination has been to show that this parasite of *Munida* really agrees in all essentials with the *Lernæodiscus* on *Galathea* and should be included in that genus. The genus *Triangulus* must therefore be withdrawn, and the parasites hitherto described as *Triangulus munidæ* should be named *Lernæodiscus munidæ*.

At the same time a careful examination of Professor Herdman's specimen and a re-examination of my preparations of *Lernæodiscus galatheæ*, have shown that I have made an error in my description and figure published in my monograph with regard to the position of one of the genital openings. This error certainly led me astray in the interpretation I put upon the orientation of the parasite, and I have now no doubt that Dr Kollmann's correction of my interpretation is amply justified, and that his own view is essentially right.

It is hoped, therefore, that in this paper the anatomy and systematics of the Rhizocephala hitherto found on the symmetrical Anomura may be

put straight, and the peculiar orientation of the parasites satisfactorily cleared up.

The specimen of *Lernæodiscus munidæ* (= *Triangulus munidæ*) found by Professor Herdman is figured from two aspects on Pl. 38. figs. 1 & 2. The surface on which the mantle-opening (*op.*) is situated (fig. 1) is applied to the thorax of the *Munida* when the tail is bent in its natural situation ; the surface depicted in fig. 2 is applied to the abdomen of the host. The peduncle (*p.*) by which attachment is effected is in a deep excavation of the body, and the mantle is thrown into several pronounced folds. The mantle-opening is asymmetrically placed on the lower right-hand corner, as shown in fig. 1, *op.* The only other features which can be observed from the outside are the broad surface of the mesentery (*m.r.*, fig. 1), which passes from the peduncle to the opening, and the much narrower hinge of the mesentery (*m.l.*, fig. 2) upon the other side.

In my previous account of *Lernæodiscus* these two hinges of the mesentery were called anterior and posterior hinges respectively, as it was my view that the long axis of the body passed through the long axis of the mesentery, but this is incorrect, as Kollmann has shown, and we should call the longer mesentery, passing from peduncle to near the opening, the right mesentery, and the smaller mesentery on the other side the left.

The disposition of the internal organs is shown in the diagrams figs. 3 & 4. In fig. 3, which is a transparent diagram of fig. 1, it is seen that the openings of the testes are situated one on each hinge of the mesentery, the right testis (*r.t.*) upon the edge of the large mesentery, the left testis (*l.t.*) upon that of the small mesentery behind. Both testis-ducts open backwards into the half of the mantle-cavity turned away from the mantle-opening. The mistake which was made in my earlier account of *Lernæodiscus* consisted in figuring the left testis as opening on that edge of the left mesentery which is turned towards the mantle-opening, and in the opposite direction to the duct and opening of the right testis. The position of the testis-openings shows that the left-hand part of fig. 3 is morphologically posterior and the right-hand part anterior, while the mid-dorsal axis passes through the peduncle at right angles to the long axis of the mesentery. The nerve-ganglion (*n.*) is situated on the large right mesentery, and the two oviducal openings are placed on the visceral mass on either side of the mantle-opening.

Fig. 4 is a diagrammatic view looking down on the peduncle and on to the mesenterial or dorsal side of the animal. Here is seen the smaller left portion of the mesentery and the larger right portion stretching to near the mantle-opening. The two testes are seen opening posteriorly to right and left of the peduncle. The nerve-ganglion (*n.*) and the two oviducal openings are seen situated on or near the right expansion of the mesentery.

Before going on to explain the peculiar asymmetrical disposition of these organs, a comparison may be made between this condition in *L. munidæ* and

the arrangement in *L. galatheæ*. Corrected diagrams of the anatomy of the latter are given in figs. 5 and 6. It will be seen from these diagrams that the positions of the testis-openings are the same as in *L. munidæ*, and not as I originally figured them in my monograph (2, Pl. 7. fig. 33). The nerve-ganglion is similarly situated on the large right mesentery, though a little further away from the mantle-opening than in *L. munidæ*. The two oviducal openings, one on each mesentery, are decidedly further away from the mantle-opening than in *L. munidæ*, and are also more definitely on the mesenterial edge and not on the wall of the visceral mass as in *L. munidæ*. How much importance is to be attached to these differences cannot be definitely stated, as the greater or less distension of the visceral mass might account to some extent for the shifting in position.

Another point of difference between *L. munidæ* and *L. galatheæ* is that in the former all the specimens hitherto obtained have the mantle-opening very definitely situated in an asymmetrical position on the right anterior corner of the body, while in *L. galatheæ* this opening is sometimes situated medianly or else deflected to the right anterior corner to a less extent than in *L. munidæ*. The fact that in *L. galatheæ* the position is variable and sometimes practically the same as in *L. munidæ*, should make one hesitate before attaching much importance to this slight point of difference.

In explaining the peculiar orientation of this parasite it is necessary to bear in mind the orientation of a more normal member of the Rhizocephala, and for this purpose *Peltogaster* may be chosen because its relations of symmetry are very simple. Fig. 7 is a diagram of the mesentery of *Peltogaster* viewed from the peduncular surface, or surface of attachment. This surface, as I have shown elsewhere (2), is the dorsal surface. The median axis of the body passes through the line AB, A being anterior and B posterior. The mantle-opening (*op.*) is seen at the anterior end of the mesentery, and the peduncle (*p.*) is seen piercing the mesentery somewhat toward its posterior end. The nerve-ganglion (*n.*) is seen on the anterior portion of the mesentery, and the genital openings are distributed on each side of the mesentery, the oviducal openings being in front and the testicular openings behind. The openings of the left side are a little in advance of those on the right side.

The way in which *Lernæodiscus* can be derived from this symmetrical condition is shown in fig. 8. Here the original long axis passes through AB, and the testes still occupy their original position, but the mesentery has been expanded laterally, especially on the right side, and the anterior portion of the mesentery in front of the peduncle has been rotated to the right, so as to be nearly at right angles to the original long axis AB. The position of the nerve-ganglion, of the oviducal openings, and of the mantle-opening relatively to the testes and the peduncle, clearly show that this rotation has taken place.

It will be seen from this account that I fully agree with Dr. Max Kollmann's conception as to the correct orientation of the parasite, according to which the surfaces applied to the host are respectively right and left, and the two hinges of the mesentery are called right and left in correspondence. But the unfortunate mistake which I made in describing the testicular openings has obscured from Dr. Kollmann the rotatory movement of the mesentery which has resulted in bringing some of the anterior organs, viz., the nerve-ganglion, mantle-opening, and one or both oviducts, on to the right side. Dr. Kollmann believes that it is easier to derive *Lernæodiscus* from *Sacculina* or *Heterosaccus* than from *Peltogaster*. As a matter of fact, this does not influence the correct orientation of the parasite, since *Sacculina* is easily derived from *Peltogaster* or *vice versa*, the organs being disposed symmetrically in relation to the mesentery in both these genera. The peculiar thing about *Sacculina* is that the symmetry of the parasite does not correspond to that of the host, the mesenterial or dorsal side of the parasite being always on the morphologically right side of the host's long axis. It has always seemed to me a curious fact that this should be so, and I am still further puzzled by the hypothesis that *Sacculina* on infecting the symmetrical Anomura should have given rise to a form like *Lernæodiscus*, which has acquired a totally different symmetry both in its own structure and in its relation to the host. As I originally pointed out, if we derive all these forms from a *Peltogaster*-like genus parasitic on the Asymmetrical Pagurids, we can understand that on infecting symmetrical forms of Anomura or Brachyura, the relation of symmetry to the host might very well undergo marked and various changes. The argument however is almost purely speculative, and does not influence our views as to the correct orientation of our parasites.

We may resume our account of the genus and species of *Lernæodiscus* as follows :—

Genus Lernæodiscus (*F. Müller* (1)).

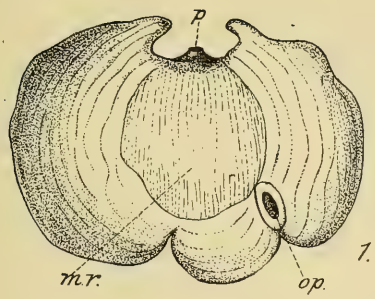
Diagnosis. External body of adult yellow.

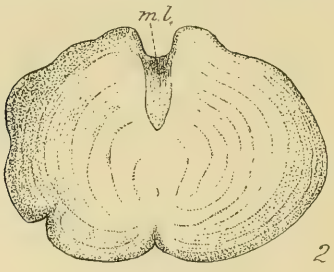
Roots yellow, widely distributed and ramifying, without lagenæ.

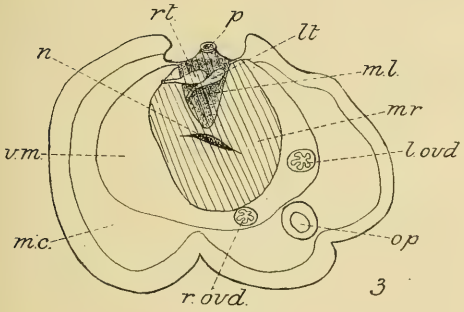
Mantle highly muscular, and thrown into lappets or folds to a greater or less extent.

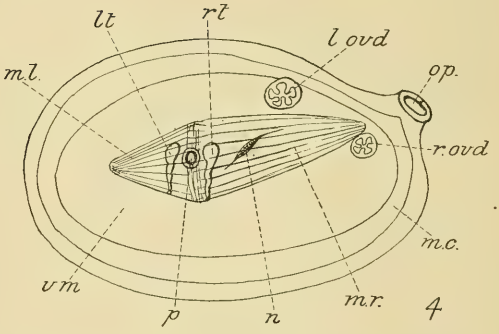
Mantle-opening situated either in the middle line or more usually deflected to the right side, relatively to the host.

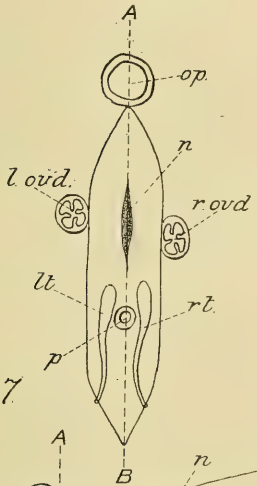
Mesentery broad, pierced by the peduncle, which separates two hinges; the morphologically right hinge being applied to the thoracic surface, the left hinge to the abdominal surface, of the host. The long axis of the parasite has undergone a peculiar rotation, which has resulted in bringing the nerve-ganglion and mantle-opening on to the right hinge of the mesentery (see figs. 7 & 8).

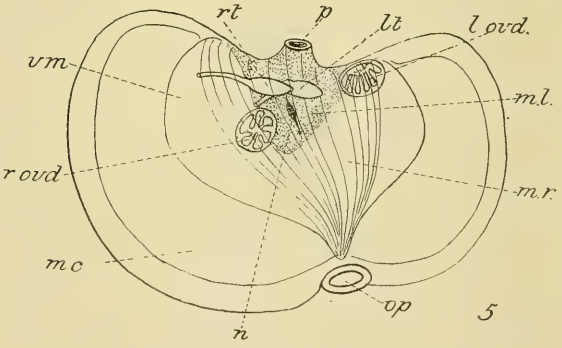


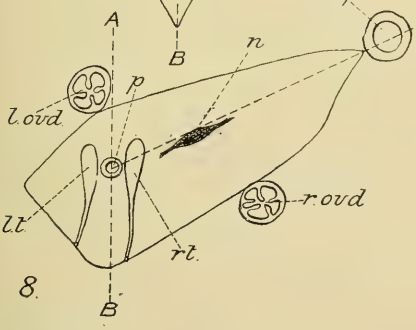


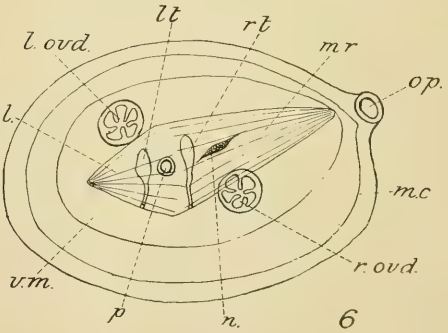












G. W. S. del.

Grout, photo sc.

LERNAEODISCUS, *F. Muell.*

Colleteric glands (oviducts) paired and convoluted.

Genital openings asymmetrically distributed owing to rotation of mesentery (see figs. 3, 4, 5, 6, 7, 8.)

Nauplius with somewhat elongated and curved frontal horns.

Parasitic on Symmetrical Decapoda Anomura.

L. PORCELLANÆ, *F. Müller* (1). Host: *Porcellana* sp. from Brazil.

Visceral mass purplish, lappets of mantle very conspicuous and indented.

L. GALATHEÆ (*G. W. Smith* (2)). Hosts: *Galathea dispersa* at Naples (Smith (2)), Gulf of Gascony (Guérin-Ganivet (5)).

Galathea intermedia, Norway (Smith (2)), Saint Vaast-la-Hougue and Gulf of Gascony (Guérin-Ganivet (5)), Banyals (Kollmann (3 & 4)).

Visceral mass yellow; lappets of mantle few and irregular.

L. STRIGOSÆ. Host: *Galathea strigosa* at Naples (Smith (2)).

Distinguished from above only by larger size, and may probably be included under *L. galatheæ*.

L. MUNIDÆ (=*Triangulus munidæ* (G. W. Smith (2)). Hosts: *Munida bamffica* from Norway (Smith (2)), and from the Shetlands (Professor W. A. Herdman). Gulf of Gascony and Brittany coasts, and African coast, south of Cape Bojador (Guérin-Ganivet (5)).

Visceral mass yellow. Lappets of mantle few and deeply indented. Mantle-opening deflected very definitely to right side. Colleteric glands (= oviducts) advanced well on to visceral mass in neighbourhood of mantle-opening. Relations of mantle and of openings of testes and of nerve-ganglion the same as in *L. galatheæ*.

Note.—It is clear from the meagre distinctions which it is possible to make between these various parasites attached to different Galatheids that it is very doubtful how far they represent good species. It is, indeed, doubtful what criterion of a good species there can be in animals which reproduce by a continuous round of self-fertilization, and are only distinguished from one another by slight differences of shape and sometimes of colour, and which offer no morphological features of outstanding importance in which they differ. I have already dealt with this fundamental difficulty in my monograph (2) pp. 166 & 167.

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EXPLANATION OF PLATE 38.

Fig 1. *Lernæodiscus munidæ.* View from right side which is applied to thorax of host, *Munida bamffica.* × 2.
2. Ditto. Viewed from left side. × 2.
3. *L. munidæ,* viewed by transparency from right side.
4. *L. munidæ,* viewed from peduncular or dorsal aspect.
5. *L. galatheæ,* viewed by transparency from right side.
6. *L. galatheæ,* viewed from peduncular or dorsal aspect.
7. Diagram of mesentery of *Peltogaster* from peduncular or dorsal aspect. AB is median longitudinal axis.
8. Diagram of mesentery of *Lernæodiscus* from dorsal aspect, showing rotation of anterior half of mesentery to right side and shifting of axis to C.

Lettering :—*p.*, peduncle of attachment; *op.*, mantle-opening; *n.*, nerve; *r.ovd.*, right oviduct; *l.ovd.*, left oviduct; *r.t.*, right testis; *l.t.*, left testis; *m.c.*, mantle-cavity; *v.m.*, visceral mass; *mr.*, right mesentery; *m.l.*, left mesentery.

Deto, a Subantarctic Genus of Terrestrial Isopoda.

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(Plates 39 & 40.)

[Read 4th June, 1914.]

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Introductory and Historical.

The genus *Deto* was established by Guérin in 1836 for a species, *D. echinata*, which was vaguely described as having been found in the East by Olivier; the chief character of the genus was that the antennæ were composed of nine joints, *i. e.* five in the peduncle and four in the flagellum, and was thus distinguished from *Oniscus*, which had three joints in the flagellum, and from *Porcellio*, which had only two. The genus was afterwards mentioned by Milne-Edwards (1840) * and Dana (1853), but no further addition to our knowledge of it was made for many years. In 1843 Krauss included the species in his list of South African Crustacea as having been collected on the sea-shore at Table Bay, and later on it was collected at the Cape by the 'Novara' Expedition. Besides the type-species, two others were afterwards described under this genus, namely, *D. spinicornis*, Brandt, from the southern shores of the Sea of Okhotsk, and *T. whitei*, Kinahan, of unknown locality; it appears likely, however, that the latter species is identical with the type-species. In 1879 Budde-Lund in his 'Prospectus generum specierumque Crustaceorum Isopodum Terrestrium,' gave the genus with these three species, and thinking that *Deto spinicornis* was rightly referred to the genus, he placed the genus under his second family *Ligiæ*. Later on, however (1885), finding, on an examination of the poorly preserved specimens in the St. Petersburg Museum, that *D. spinicornis* should probably be referred to *Trichoniscus*, and having had an opportunity of examining two species really belonging to *Deto*, he came to the conclusion that the genus should come near to *Oniscus*, and that it is perhaps not

* The references are made by the year of publication to the bibliographical list on pp. 454, 455.

distinct from that genus. In his 'Crustacea Isopoda Terrestria' (1885, p. 233), he gave a diagnosis of the genus and included under it two species, *D. echinata*, Guérin, and a new species *D. acinosa*, of both of which he had examined specimens from South Africa in the St. Petersburg Museum; he mentioned also *D. whitei*, but stated that it is probably the same as *D. echinata*.

For many years after this no further addition was made to our knowledge of this genus, but in 1906, Budde-Lund, having had an opportunity of examining specimens of a *Deto* collected by the German Polar Expedition at St. Paul's Island, in the Indian Ocean, gave a revision of the genus, describing these specimens as a new species, *D. armata*, and established two new species, *D. magnifica* and *D. robusta*, on three specimens from the Auckland Islands, New Zealand, preserved in the Dresden Museum. He also assigned to the genus *Deto* a species that had been described in 1879 by Mr. G. M. Thomson under the name *Actæcia aucklandiæ*, and which, in 1901, I had provisionally placed under *Scyphax*; also another species from New Zealand described in 1885 by Filhol under the name *Oniscus novæ-zealandiæ*, and the species *Philougria marina*, described by me in 1884 from the East Coast of New South Wales. Budde-Lund thus gives eight species under the genus, but of these, two, *D. magnifica* and *D. robusta*, are, I think, undoubtedly synonyms of *D. aucklandiæ*. In 1910 I pointed this out and stated that two species of Isopoda, described from Chili by Nicolet in 1849, namely, *Oniscus bucculentus* and *O. tuberculatus*, were male and female of a species of *Deto*, and were probably identical with *O. novæ-zealandiæ*, Filhol.

Before the publication of Budde-Lund's paper in 1906, I had obtained specimens of the two New Zealand species and had commenced a report on the genus, describing the mouth-parts and the pleopoda, which, up to that time, were practically unknown, as the only specimens available to Budde-Lund in 1885 had been dried or poorly preserved. My paper was long delayed through lack of sufficient specimens of the different species, but later on the Director of the South African Museum very kindly supplied me with specimens of the two species found in South Africa, and I have recently received additional specimens of *D. novæ-zealandiæ*, Filhol, from Stewart Island, New Zealand. I have thus been able to see specimens of all the species that I consider to be good ones, except *D. armata*, Budde-Lund, and in this paper I endeavour to give a fairly full account of the genus.

The genus is an extremely interesting one on account of the large size and striking appearance of some of the species, the remarkable and varied sexual differences, the strictly maritime habitat of all the species, and the geographical distribution.

I recognise six species—two from South Africa, two from New Zealand (one of which is found also in South America), another species from St. Paul's Island in the Indian Ocean, and the sixth from the East Coast of Australia.

In his last Revision of the Terrestrial Isopoda, Budde-Lund (1904) placed *Deto* under a subfamily *Detoninæ* of the Oniscidæ, and Stebbing (1910, p. 444) has since raised this to the rank of a family. In 1901 I placed the genera *Scyphax*, Dana, *Actœcia*, Dana, and *Scyphoniscus*, Chilton, under Scyphacidæ, a family distinct from, though closely allied to, the Oniscidæ; in this family I had also included *Actœcia aucklandiæ* (G. M. Thomson), of which I had been able to examine a single female specimen, but whose affinities to *Deto* I had not then recognised. An examination of the whole of the species shows that *Deto* would readily come under this family as then defined by me, and the genera mentioned seem to be sufficiently closely allied to justify us in placing them in one family rather than in establishing three or four separate families or subfamilies for their reception.

I shall now give diagnoses of the genus and of the different species of *Deto*, reserving some general remarks on the genus for the conclusion of the paper.

Family SCYPHACIDÆ.

Scyphacinæ, Dana, 1853, p. 716.
Scyphacidæ, Chilton, 1901, p. 121.
„ Richardson, 1905, p. 671.

The description of this family given in 1901 was as follows:—"Mandibles without molar tubercle, its place being taken by a tuft of long stiff setæ or bristles; inner lobe of first maxilla with two plumose bristles; maxillipeds with the terminal joints fairly well developed, lamellar, longer than the masticatory lobe; external male organ single."

The characters of the genus *Deto* come well within this definition.

Genus Deto, *Guérin*, 1834.

Deto, Guérin, 1836, notice 21, p. 1.
„ Milne-Edwards, 1840, vol. iii. p. 174.
„ Budde-Lund, 1879, p. 9.
„ Budde-Lund, 1885, p. 233.
„ Budde-Lund, 1906, p. 84.
„ Chilton, 1909, p. 666.
„ Stebbing, 1910, p. 444.

The generic description given by Budde-Lund in 1885 was based on the examination of imperfect specimens of two species only; in 1906, having been able to examine additional specimens, including well-preserved specimens

of the new species *Deto armata*, he gave an amended diagnosis, the main characters of which are included in the following diagnosis which I now suggest:—

Generic diagnosis.—General shape of body oblong-oval, somewhat depressed; animal not capable of rolling itself into a ball; epimera lamellarly expanded * ; dorsal surface usually with spines or tubercles which are better developed in the male than in the female ; pleon not abruptly narrower than peræon ; epimera of third, fourth, and fifth segments well developed. Head with lateral processes forming broad lobes.

Eyes of moderate size, with many ocelli.

Antennæ with flagellum four-jointed.

Mandibles with one penicil behind the cutting-edge.

Maxillipeds with palp longer than masticatory lobe, and showing indications of being formed of three or four joints.

Exopoda of the pleopoda opercular, and containing no special branchial organ.

Uropoda produced, reaching considerably beyond the terminal segment.

In addition to the points given above, there are several characters common to these species which may be mentioned here to avoid repetition.

Sexual dimorphism is very marked and affects the surface of the body and the antennæ, but not the peræopoda or uropoda, which are the parts that usually show sexual differences in *Trichoniscus*, *Porcellio*, &c.

The antennæ are long and stout, usually stouter in the male than in the female.

The mouth-parts are on the same general type of those of *Oniscus*, and are fairly uniform throughout the genus. I have described them in greater detail for *D. aucklandiæ* and *D. bucculenta*, but a few points may be given here.

The mandibles are strong ; the accessory appendage differs on the two sides, in the left mandible being formed of two or three strongly chitinised teeth similar to the outer cutting-edge, in the right it is shorter and ends in a crown of small teeth of varying sizes ; at the base of the accessory appendage in both mandibles is a hairy lappet which may bear one or two stout setæ or "penicils" similar to the single penicil between the lappet and the tuft of long bristles representing the molar tubercle.

The lower lip consists of two rounded lobes separated apparently to the base, but connected proximally by the inner more membranous lobes which appear capable of being folded together at right angles to the lip, and when

* In the female of *Deto aucklandiæ* the epimera of segments 2, 3, and 4 of the peræon are separated from their segments by a slight groove or apparent suture; in the males of this species and in both sexes of the other species the epimera are quite continuous with their segments, the junction not being marked by any groove or suture.

spread out of filling the space between the outer lobes when they are separated laterally.

The first maxilla is of normal shape, its narrow inner lobe bearing two densely hairy bristles.

The second maxilla is somewhat curved near the base, but the outer edge is not angularly produced as in *Oniscus*, &c.

The maxillipeds have the epipod large, flanking the basal part, and tapering distally; the second joint is broad, but not so much expanded as in *Oniscus*; the palp is longer than the masticatory lobe and shows indications of the separate joints of which it is composed.

The pleopoda are of the same type as those of the Oniscidæ; the inner ramus of the second pair in the male is particularly long, terminating in a very long slender lash.

The uropoda vary in the different species and are described below; they are the same in the two sexes.

Budde-Lund (1906) divided the genus into two subgenera with the following characters:—

Subgenus *Deto*:

1. Antennæ rather long and slender; joints of flagellum fairly long.
2. Palp of maxillipeds a little longer than the masticatory lobe.
3. Endopod of uropod short, scarcely reaching to the middle of the exopod.

Subgenus *Vinneta*:

1. Antennæ rather short, stout; joints of flagellum very short.
2. Palp of maxillipeds much longer than the masticatory lobe.
3. Endopod of uropod rather long, longer than exopod.

Of these three characters the first two do not appear to me to be reliable for subgeneric characters. It will be seen from the descriptions given below that in most of the species the antennæ differ considerably in the two sexes, and that while the male may have the antenna very stout, in the female it may be fairly slender, with the joints of the flagellum of moderate length. Again, the palp of the maxillipeds is in all cases longer than the masticatory lobes, and the differences in its length are not sufficient to be of much importance.

The third point seems, however, to be a good one and enables the species at present known to be separated into two groups, one including the species found in New Zealand and South America, and the other the species in South Africa, St. Paul's (Indian Ocean), and Australia.

Owing to the great differences between the male and the female, and the fact that in this, as in many genera of the Isopoda and Amphipoda, the females of the different species are nearly alike, it is hopeless to try to distinguish between the species without making use of the characters of

the fully developed male ; unfortunately the male in *D. marina* is not known. The others may, however, be distinguished as follows :—

A. Uropod with exopod reaching much beyond the endopod Subgenus *Deto*, Budde-Lund.
 1. Male with a pair of long spines on each segment of peræon, pleon without spines *D. echinata.*
 2. Male with a pair of spines (or prominent tubercles) on each segment of peræon, and on third and fourth segments of pleon *D. armata.*
 3. Male with a pair of tubercles (not spines) on each segment of peræon *D. acinosa.*
 4. Male unknown; female with surface granular, or with low tubercles only *D. marina.*

B. Uropod with exopod not reaching beyond endopod. Subgenus *Vinneta*, Budde-Lund.
 1. Male with lateral portions of first segment of peræon not expanded; surface of peræon with prominent blunt spines *D. aucklandiæ.*
 2. Male with lateral portions of first segment of peræon forming balloon-like expansions; surface of peræon with irregular pointed tubercles *D. bucculenta.*

DETO ECHINATA, *Guérin*. (Pl. 39. figs. 1–3.)

Deto echinata, Guérin, 1836, notice 21, p. 2, pl. 14.
„ „ Milne-Edwards, 1840, vol. iii. p. 174.
„ „ Krauss, 1843, p. 63.
„ „ Heller, 1868, p. 137.
„ „ Budde-Lund, 1879, p. 9.
„ „ Budde-Lund, 1885, p. 234.
„ „ Stebbing, 1893, p. 431.
„ „ Budde-Lund, 1906, p. 85.
„ „ Stebbing, 1910, p. 444.
? *Deto Whitei*, Kinahan, Dublin Zool. Bot. Assoc. i. p. 199, pl. 19, fig. 6; *see also* Ann. & Mag. Nat Hist. ser. 5, vol. xvii. p. 83.

Male.—Oblong-oval, more than twice as long as broad. Head with a prominent subacute tubercle on each side near the posterior margin and internal to the eyes, with another smaller tubercle anterior and interior to the first ; rest of surface granular ; lateral lobes moderately large, directed outwards and forwards, their extremities broadly rounded.

Each segment of peræon with a pair of long acute spines, straight or slightly curved, arising near the posterior margin and projecting vertically, those on the posterior segments directed also a little backwards ; the spines on the first segment are the shortest, those on the succeeding segments longer till the fourth and fifth, which are subequal and much longer than the segment from which they arise, each of the sixth and seventh a little shorter than the preceding one. Rest of surface of peræon finely granular

or slightly rugose, more especially on the anterior segments. Epimera large, each with a faint ridge running backwards and outwards towards its posterior angle.

Surface of pleon smooth ; epimera of third, fourth, and fifth segments largely developed, last segment triangular, nearly twice as broad as long, apex rounded.

Uropoda with basal joint broad, reaching slightly beyond the end of the last segment, upper surface raised in middle into a longitudinal keel, lateral margin somewhat expanded ; outer ramus long, lanceolate, fully twice as long as base ; inner ramus only about as long as the base, not in contact with its fellow on the other side.

Female.—Differs from male in having the body more oval, the long spines represented only by rounded tubercles, the oblique ridges on the epimera rather better marked, and the antennæ more slender.

Length of male (without uropods) 22 mm., breadth 10 mm.

Length of female 20 mm., breadth 9 mm.

Colour. Slaty grey, with marbled markings of lighter colour.

Habitat. Table Bay, Cape Colony, collected on sea-shore with *Ligia glabrata* by Krauss ; collected at "The Cape" by the 'Novara' Expedition ; the specimens from the South African Museum submitted to me are labelled :— "Sea-shore at Hout Bay, Cape Peninsula, W. L. Sclater coll., April 1901," and "Sea-shore at Scuilphoek, 2 to 3 miles south of Hermanuspetrusfontein, Caledon District, Cape Colony, R. M. Lightfoot coll., February 1903."

Of this species I have seen several males, but only one female ; the males are all of about the same size, and have the pair of long slender spines on each segment of the peræon well developed ; the spines are considerably longer than those of *D. armata* as figured by Budde-Lund. In the single female the dorsal surface is granular, more so than in the male, and the spines are represented only by small, rounded, light-coloured tubercles projecting only slightly above the general surface.

The species appears to be considerably larger than *D. acinosa*, but closely resembles that species in its appendages.

Deto acinosa, *Budde-Lund.* (Pl. **39.** figs. 4–18.)

Deto acinosa, Budde-Lund, 1885, p. 235.
„ „ Stebbing, 1893, p. 431.
„ „ Budde-Lund, 1906, p. 85.

Male.—Oblong-oval, fairly convex. Head with a rather large rounded tubercle on each side near the posterior border and internal to the eyes, rest of surface coarsely granular. Each segment of the peræon with a large subacute tubercle on each side near the posterior margin, projecting upwards and backwards to a distance equal to half the length of the segment from

which it arises ; on the anterior segments, especially the first, the surface in front of these tubercles shows a few irregular granulations ; epimera well developed, not separated from their segments by a suture, each with a faint oblique ridge running outwards and backwards to the posterior angle, the ridge best marked on the posterior segments. Pleon with surface smooth, epimera of segments 3, 4, and 5 well developed ; last segment triangular, its extremity rounded.

Female.—Differs from the male in lacking the prominent tubercles on the segments of the peræon ; surface of head and peræon granular, the position of the tubercles on the peræon represented by a granule slightly more prominent than the others. Antennæ rather more slender than in the male.

Length 13 mm., width 6·5 mm.

Colour. Slaty grey, tips of tubercles and lateral portions lighter in colour, some lighter markings also on the general surface.

Habitat. Cape Peninsula, South Africa, on sea-shore ; two specimens in the St. Petersburg Museum from "Africa"; many specimens in South African Museum from "Sea-shore at Sea Point, Cape Peninsula, R. M. Lightfoot coll."

Of this species I have seen many specimens of both sexes and of different sizes. It is a smaller species than *D. echinata*, and does not present such marked sexual differences, though the pointed tubercles or teeth on the peræon are quite prominent in the adult male ; in the figure they are perhaps made a little too prominent.

The antenna of the male is shown in fig. 6 ; it is similar to that of *D. echinata*, but has the joints of the flagellum slightly longer.

The upper lip (fig. 7) has the margin broadly rounded and fringed with short setæ.

The mandibles (fig. 8) have only about ten long bristles in the tuft representing the molar tubercle, and these are almost smooth except towards the end, but otherwise do not differ from those of *D. aucklandiæ*.

The lower lip (fig. 9) has the outer lobes with a slight notch near the apex, inner lobes narrow and delicate.

The first maxillæ are normal.

In the second maxilla (fig. 10) the outer lobe is nearly as broad as the inner, but not so thickly setose.

The maxillipeds (fig. 11) have the palp not much longer than the masticatory lobe, which is oblong, truncate at the end, and bears near the inner angle a small hairy appendage like a short, stout, plumose bristle.

The peræopoda (figs. 12 & 13) increase slightly in length posteriorly. They are rather spiny ; the dactyl bears a long split seta longer than the others, which appears to represent the dactylar seta, but it is not very prominent, especially in older specimens.

In the first pleopod of the male (fig. 14) the male organ is about two-thirds as long as the narrow endopod, which is grooved on its posterior aspect; the exopod is short and not produced at its inner side, its extremity being regularly rounded.

The second pleopod of the male (fig. 15) has the endopod extremely long and slender; the exopod is somewhat produced at its inner angle, and has a few very delicate plumose setæ on the outer margin.

In the female the exopod of the first pleopod (fig. 16) is short and broad with regularly curved margins, its extremity is slightly produced on the inner side and is broadly rounded; no endopod was seen.

The second pleopod of the female (fig. 17) has the exopod larger with inner angle more produced, margins with a few delicate setæ; the endopod forms a short triangular process.

The uropoda (fig. 18) are practically the same as in *D. echinata*.

DETO ARMATA, *Budde-Lund*.

Deto armata, Budde-Lund, 1906, p. 86, pl. 4, figs. 26–36.

Specific description.—Similar to *D. echinata*, but smaller and somewhat narrower. Head, each segment of peræon, and third and fourth segments of pleon each bearing a pair of spines which are much larger in the male than in the female; general surface minutely granular. Terminal segment with apex triangularly produced, subacute.

Antennæ long, slender, fourth joint of flagellum of moderate size. Maxillipeds with the palp a little longer than the masticatory lobe Legs supplied with moderately long spines. Pleopoda and uropoda apparently as in *D. echinata*.

Length 12 mm.

Habitat. St. Paul's Island, Indian Ocean; collected by German South-Polar Expedition in 1903.

I have not seen specimens of this species, and have drawn up the specific diagnosis from the description and figures given by Budde-Lund.

The species appears to be very similar to *D. echinata*, but differs in having a pair of spines on the third and fourth segments of the pleon as well as on the peræon. Budde-Lund says nothing about the length of these spines, but if the specimen he figures is a male (as it presumably is), they are not so long as in fully grown specimens of *D. echinata*; Budde-Lund, however, gives the length of the animal as 12 mm. only, and the specimen figured may not be fully grown.

The mouth-parts, peræopoda, and pleopoda of this species have been figured by Budde-Lund; they appear to present a close general resemblance to those of *D. echinata* and *D. acinosa*.

DETO MARINA (*Chilton*). (Pl. 39. figs. 19–23.)

Philougria marina, Chilton, 1884, p. 463, pl. 11.
" " Chilton, 1901, p. 128.
" " Stebbing, 1900, p. 565.
Deto marina, Budde-Lund, 1906, p. 85, pl. 4, figs. 39–41.

Specific description.—Body oblong-oval, length rather more than twice the greatest breadth. Head with surface irregularly tuberculate, front projecting into a triangular lobe ending subacutely, lateral lobes very broad, occupying nearly all the side-margin ; eyes large, on rounded prominences raised above the lateral lobes. Surface of peræon somewhat scabrous, with a few low inconspicuous rounded tubercles, most marked on the anterior segments ; epimera not very greatly expanded, each with a slight oblique ridge running outwards and backwards to the posterior angle. Segments 3, 4, and 5 of pleon with well-developed epimera which have the posterior angles acute, terminal segment triangular, sides slightly concave, extremity broadly rounded.

Antennæ (fig. 20) about one-third the length of the body, slender, fifth joint slightly longer than the third and fourth together ; flagellum as long as the fourth, its first three joints subequal in length, fourth slender, about half as long as the preceding, and merging almost imperceptibly into a pencil of very short setæ ; whole surface of antenna covered with minute short spinules and fine short setæ.

Legs (figs. 21 & 22) subequal in length, the posterior ones only slightly increasing in length ; all rather spiny, the largest spine, which splits towards the end, being situated near the distal end of the carpus.

Uropoda (fig. 23) with base broad, reaching to the end of the terminal segment ; outer ramus longer than base, tapering to the end, which bears a few short setæ ; inner ramus arising more anteriorly, slender, only slightly tapering, ending with pencil of long setæ.

Length of largest specimen (a female with brood-plates developed) 6 mm.

Colour. Yellowish, with marking of a dark brown.

Habitat. Coogee Bay, near Port Jackson, New South Wales (Chas. Chilton coll., January 1884).

This species is known only from Coogee Bay, near Port Jackson, New South Wales, where I collected it in January 1884; it was found near high-water mark, and most of the specimens were taken out of the water, which was nearly high tide at the time. Unfortunately my specimens are all small; the largest is 6 mm. long, and is a female with brood-pouches developed; the others are probably immature. I can find no adult male among my specimens, and am unable therefore to say whether there are any secondary sexual characters or not. Several friends, especially Mr. T. Whitelegge, of the Australian Museum, have since endeavoured to collect additional specimens for me from the same locality, but without success.

In its small size, more slender antennæ, and in the slender spiny peræopoda and the uropoda, this species at first shows a general resemblance to a *Trichoniscus*; the mouth-parts are, however, as was first pointed out by Stebbing (1900, p. 565), quite different, and the species is a true *Deto*.

The mouth-parts are similar to those of *D. acinosa*, and do not require special notice; the maxillipeds have been figured by Budde-Lund (1906, pl. 4, fig. 40) from a specimen given by me to the Zoological Museum of Dundee University College.

The legs (figs. 21 & 22) are slender, and in the arrangement of the spines, particularly of the large split spine towards the distal end of the carpus, are very similar to those of *Trichoniscus* and allied genera; the dactylar seta is fairly prominent—it has only two branches, one of which bears a small knob at the end.

The adult male is not known; it will be interesting to see in what characters it differs from the female.

DETO AUCKLANDIÆ (*G. M. Thomson*). (Pl. **39.** figs. 24–30, and Pl. **40.** figs. 31–44.)

Actæcia aucklandiæ, G. M. Thomson, 1879, p. 249.
„ „ Budde-Lund, 1885, p. 239.
„ „ Filhol, 1885, p. 443.
Scyphax (?) *aucklandiæ*, Chilton, 1901, p. 126, pl. 15, fig. 2.
Deto aucklandiæ, Chilton, 1906, p. 273.
„ „ Budde-Lund, 1906, p. 87.
„ „ Chilton, 1909, p. 666.
„ „ Chilton, 1910, p. 288.
Deto magnifica, Budde-Lund, 1906, p. 86.
Deto robusta, Budde-Lund, 1906, p. 86.

Specific description.—Male. Oblong-oval, moderately convex, head strongly tuberculated, with a raised oblique ridge running from near the centre outwards and backwards to the posterior margin; in the centre between these ridges are four tubercles, the posterior two larger than the two anterior, other small tubercles near the frontal margin; lateral lobes large, directed outwards, roundly tetragonal.

First segment of peræon slightly longer than the others, which are subequal, each segment bearing a transverse row of tubercles or rounded blunt-ended spines, which are directed upwards and a little backwards, the lateral ones the largest and longest, the others gradually diminishing in size towards the median line; in most cases there are ten tubercles in each row, but there are usually fewer on the first and last segments of the peræon; in the first two segments there are usually some slight tubercles in front of the transverse row. Pleon with first two segments short and without epimeral expansions, third, fourth, and fifth with large epimeral expansions

which end subacutely, a transverse row of small rounded tubercles on the second, third, fourth, and fifth segments; last segment without tubercles, surface slightly granular, much broader than long, extremity broadly rounded.

Eyes somewhat small, narrow-oblong.

Antennæ extremely thick and stout, second joint of peduncle longer than the first or third, fourth joint slightly shorter than fifth, which is narrowed at the base and expanded distally; flagellum much expanded, of three subequal joints, each much broader than long, the minute fourth joint hardly visible; last joint of peduncle and the flagellum densely covered with short woolly hairs.

Legs subequal with a few short spinules, inner margins with woolly hairs.

Uropoda with the basal portion very broad, meeting in the median line and extending slightly beyond the end of the terminal segment; outer margin expanded and produced at the outer posterior angle, inner rami contiguous along the median line, longer than the outer rami, both rami rounded at the end and covered with minute setæ.

Length of largest specimen 24 mm.; greatest breadth 11 mm.

Colour. Slaty grey.

Female.—Differing from the male in the following points:—Body broader and less convex, the tubercles on the head and peræon much smaller and less prominent, forming only small rounded tubercles; epimeral expansions, especially on the posterior segments, showing an oblique ridge running backwards and outwards; antennæ stout but much more slender than those of the male, the fifth joint of the peduncle slightly sinuous, and when folded back fitting into a groove on the outer surface of the fourth joint; flagellum about two-thirds as long as the last joint of the peduncle, its joints as long as broad or longer, the first two subequal, the third as long as these two together, fourth minute.

Length 19 mm.; greatest breadth 11 mm.

Colour. Slaty grey.

Habitat. Ewing Island, in the Auckland Islands group, New Zealand; found on the sea-shore (collected by Dr. L. Cockayne, F.R.S., and Mr. E. Jennings).

This remarkably large and striking species has been found only in the Auckland Islands, where its lives under seaweed, etc., on the sea-shore. Filhol gives the locality as "Nord de la Nouvelle-Zélande, Auckland," but this has no doubt arisen from the unfortunate confusion of the Auckland Islands, which lie about 200 miles to the south of New Zealand, with the Auckland City and Province in the north of New Zealand. I have seen only about half-a-dozen specimens, all from Ewing Island, these being all males except one. The differences between the two sexes are extremely

marked, especially in the full-grown males ; two of my male specimens are apparently not quite fully grown and have the antennæ considerably more slender than is shown in fig. 27, and more approaching the conditions found in the female, though much stouter; the prominence of the tubercles on the peræon is also less marked in the immature males.

I think there can be no doubt that *D. magnifica*, Budde-Lund, and *D. robusta*, Budde-Lund, are synonyms of this species. Budde-Lund established these two species on three specimens from the Auckland Islands in the Dresden Museum; of *D. magnifica* he had only one imperfect specimen, and states that it is perhaps the same as *D. aucklandiæ*. Of *D. robusta* he had one male and one female, and apparently based the specific distinction largely on the characters of the male, the differences of which from the female had not previously been fully pointed out. In his original description, Mr. Thomson, by an error, interchanged the sexes and described the female as being provided with the stout obtuse spines.

The specific diagnosis given above may be supplemented by the following more detailed description of the appendages :—

Antennules (fig. 26) small but noticeable, first joint as long as the second but shorter, third about half as long as the second, narrower, and tapering ; all covered with fine short hairs, two or three minute olfactory setæ near the end of the third.

The antennæ in the fully grown males (fig. 27) are particularly broad and powerful, all the joints being broadened and having the surface uneven, as shown in the figure ; the fifth joint is about the same length as the fourth or only slightly longer, and lies nearly at right angles to it, the outer surface of the fourth being hollowed out towards the extremity to receive it ; the flagellum is about half as long as the fifth joint and shows three subequal joints, each broader than long, the very small fourth joint being almost concealed in the fine downy hairs which cover the flagellum and the terminal portion of the peduncle.

In the female the antennæ (fig. 28) are very much more slender, but show the same proportions, except that the third joint of the flagellum is longer than either of the first two, which are subequal and about as broad as long ; the fourth joint is small, though readily noticeable ; the fine hairs found in the male are hardly represented.

In immature males the antennæ tend to resemble those of the female.

Upper lip with extremity roundly truncate.

The mandibles are large and strongly chitinised, of the same type as in *Oniscus*. In the left mandible (fig. 30) the cutting part is composed of two strong teeth somewhat rounded and dark brown in colour, within it lies the accessory appendage also composed of two strongly chitinised teeth, brown in colour, and bearing at its base a membranous, hairy lappet densely fringed with setæ ; this is followed by a single "penicil," and then by the brush-like

recurved setæ replacing the molar tubercle; this contains a large number of long, stiff, curving bristles of varying length. In the right mandible (fig. 29) the general structure is the same, but the accessory lobe bears a number of small sharp teeth instead of ending in two large teeth as in the left mandible.

The lower lip (fig. 31) is formed of two rounded lobes, the cleft between them reaching to the base, but they are united in the proximal half by an inner folded central lobe, the inner margins and the distal half of the outer margin of the outer lobes being densely fringed with long fine setæ.

The first maxilla (fig. 32) has the usual form, the extremity of the outer lobe bears about ten stoutly chitinised spines of different sizes, its inner margin is fringed near the middle with a number of very fine delicate setæ; the inner lobe is moderately stout and bears at the end the usual two brush-like setæ.

The second maxilla (fig. 33) is slightly curved, its outer lobe is much smaller than the inner, both being supplied with the usual setæ; the distal portion of the outer margin is fringed with slender setæ, but there are a few on the inner margin near the base.

The maxillipeds (figs. 34 & 35) have the epipod long, about as long as the broad second joint, tapering towards the subacute extremity, its margin fringed with delicate setæ; the enlarged second joint is expanded into a rounded lobe at the outer distal angle, fringed with long fine setæ; the palp has a short joint at the base, and the terminal portion, though formed of a single piece, is lobed on the inner side, indicating that it is formed of four joints, each lobe bears a large number of short stout setæ; the inner, masticatory, lobe of the maxilliped is rectangular, truncate at the extremity, densely covered with fine setæ, at the inner distal angle it bears a minute appendage covered with very short setæ.

The legs (figs. 36 & 37) are all of about equal length, the posterior ones being only slightly longer than the anterior; in all of them the ischium is long, being about two-thirds the length of the basis, and it expands slightly distally, the merus is about subequal with the carpus, and the propod is slightly longer than either of the two preceding joints, but considerably narrower; the dactyl is short and stout and has the basal portion thickly covered with fine short hairs; there appears to be no special dactylar seta. On all of the joints, as shown in the figures, there are a few rather short, stout spines, and the inner margins of most of the joints, particularly the ischium, merus, carpus, and propod, are thickly covered with fine, very short, setæ. None of the legs is specially modified in the males.

The first pleopod of the male (figs. 38 & 39) has the basal joint produced laterally into a broad lamellar expansion with its angles rounded; the exopod is operculiform, broadest near the base and tapering to a subacute apex; the endopod is specially modified, it is somewhat broader at the base and then

narrows, remaining about the same width nearly to the extremity where it narrows somewhat suddenly and has the apex pointing slightly outwards, along its posterior margin it bears a groove. The male organ is short, reaching only about halfway along the endopod, the distal third is narrowed and it is slightly emarginate at the extremity.

The second pleopod (fig. 40) has the basal portion and the exopod similar to those of the first, except that the lateral expansion of the former is smaller ; the convex inner margin of the exopod is thickly fringed with fine short setæ ; the endopod is greatly narrowed and elongated and appears to be divided into two joints, the basal one short and oblong, the terminal one very long, nearly twice the length of the exopod, and ending in an extremely fine styliform process—along the anterior surface of this joint is a groove which appears to fit against the corresponding groove of the first exopod, doubtless thus forming a tube for the passage of the semen.

The third pleopod has the exopod operculiform and similar to those of the preceding pleopoda, the endopod is branchial, much shorter than the exopod, and somewhat quadrangular in shape, with rounded angles. The fourth (fig. 41) and fifth pleopoda are similar in shape and structure to the third.

In the female the first pleopod (fig. 42) has the outer ramus of the same shape as in the male but considerably smaller ; it has the outer margin strongly convex proximally and concave distally, but is not distinctly bilobed as in *Oniscus* ; the inner ramus was not seen, it appears to be either absent or very small. The second pleopod of the female (fig. 43) has the outer ramus larger and of the same shape : arising from the basal portion near the middle line is a small triangular appendage which appears to represent the inner ramus ; it is firm and chitinous like the outer ramus and is not branchial in function.

The uropoda (fig. 44) have already been described ; the upper surface of the base is somewhat keeled in the centre, and has the lateral portion expanded and slightly concave above ; the uropoda are practically the same in both sexes.

Deto bucculenta (*Nicolet*). (Pl. 40. figs. 45–59.)

Oniscus bucculentus, Nicolet (♂), 1849, p. 267, pl. 3, fig. 9.
„ „ Budde-Lund, 1885, p. 206.
Oniscus tuberculatus, Nicolet (♀), 1849, p. 268.
„ „ Budde-Lund, 1885, p. 206.
Oniscus novæ-zealandiæ, Filhol, 1885, p. 441, pl. 54, figs. 7–8.
Scyphax (?) *aucklandiæ*, Chilton, 1901, p. 126 (in part).
Deto novæ-zealandiæ, Chilton, 1906, p. 273.
„ „ Budde-Lund, 1906, p. 87.
„ „ Chilton, 1909, p. 667.
„ „ Chilton, 1910, p. 288.

Specific description.—Male. Body oblong-oval; cephalon with front not much produced in centre; lateral lobes large with outline subquadrangular, their surface fairly smooth, rest of dorsal surface of head irregularly tuberculate. First segment of peræon much wider than the cephalon, posterior margin straight with lateral angles broadly rounded, central portion with two transverse rows of tubercles, lateral portions expanded and swollen into two balloon-like bodies with outer margin convex and surface very finely spinulose. Second, third, and fourth segments with posterior margins straight or only slightly sinuous at the sides, lateral angles slightly produced; fifth, sixth, and seventh with posterior margins concave, and lateral angles more or less acutely produced. All the segments with the central parts bearing two transverse rows of irregular tubercles, some of them, especially the lateral ones, pointed at apex; on the epimera is a single row of tubercles or a raised ridge running obliquely outwards and backwards to the postero-lateral angle.

Third, fourth, and fifth segments of pleon with large epimera, and a single row of tubercles on central portion. Telson short, much broader than long, triangular, apex broadly rounded, sides a little concave.

Antennæ stout, nearly half as long as body; first three joints short, subequal, fourth nearly twice as long as third and about twice as long as broad, fifth considerably longer than fourth, narrowed at base; flagellum as long as fourth joint, first three segments subequal, fourth smaller but of moderate size; whole antenna densely hirsute, especially towards the end.

Uropoda with base broad, flattened, the two meeting in median line, dorsal surface with a slight longitudinal ridge down the centre, outer margin thin, produced, postero-lateral angle acute, produced; inner ramus inserted much anterior to outer, outer arising from a concavity at end of base, both reaching to same point; endopod with a few fairly long setæ at end, short setæ on other parts and on the exopod.

Female.—Differs from male in lacking the large balloon-like expansions of the first segment of the peræon, and in having the tubercles on the dorsal surface of the body much less developed and the antennæ more slender.

Length of male specimen 11 mm.; breadth 5 mm.; female rather smaller.

Colour. Slaty grey.

Habitat. Chatham Islands (*Miss S. D. Shand*) and Stewart Island (*Mr. Walter Traill & Prof. Benham*), New Zealand; Valparaiso Bay, South America (*Nicolet*).

I first recognised this species from specimens, unfortunately poorly preserved, sent to me from the Chatham Islands by Miss S. D. Shand; one female was taken at Port Pegasus, Stewart Island, during the Philosophical Institute of Canterbury's Expedition to the Subantarctic Islands of

New Zealand in 1907; subsequently Prof. Benham sent me a male and a female from the same locality, and quite recently Mr. Walter Traill has sent me two males and one female from the island of Ulva in Paterson Inlet, Stewart Island.

Filhol states that he collected the species near Wellington, but, though I have made many collections there, both personally and by the help of friends, I have not succeeded in finding it in that locality.

I feel confident that the species described by Nicolet from Chili are the same as the New Zealand one; his figures * and description agree throughout, the large expansions of the first peræon segment in the male are quite characteristic, and his figure of the antenna of *Oniscus bucculentus* agrees closely with the one I now give (fig. 48), which was drawn before I had seen the plates of Nicolet's work. The form Nicolet described as *O. tuberculatus* is evidently the female, and, though he described it as a different species, he recognised that it resembled *O. bucculentus* except for the secondary sexual characters peculiar to the male.

A comparison of this species with *D. aucklandiæ* gives us a good example of the apparent capriciousness in the secondary sexual characters of these Crustacea. In *D. aucklandiæ* the differences are confined to the antennæ and the tuberculation of the body; in *D. bucculentus* we have similar sexual differences, though to a less degree, but in addition we have in the male the extraordinary balloon-like expansions on the first peræon segment, for which I know of no parallel among the Crustacea. What the function of these can be it is difficult to imagine; they appear, however, only to be developed to the full extent in the adult male; I have one specimen, a male, showing the usual male structure of the first and second pleopods, but the expansions, though large, are not so large as shown in fig. 45, taken from an older male, and their outline is slightly angular, indicating the normal shape of the segment; Filhol's figure shows a male in about the same stage of development; his figure, however, is poor, and shows the legs much too long—when in their normal position they are not visible in dorsal view.

Fig. 45 of the male is taken from a Chatham Islands specimen; in it the balloon-like expansions are somewhat flattened below, but very convex above, and the surface is thickly covered with minute spinules just as is shown in Nicolet's figure. In a specimen subsequently received from Paterson's Inlet, Stewart Island, the expansions are still larger and somewhat more separated from the segment itself; they are almost globular and strongly convex below as well as above, and the surface is almost smooth, showing only a slight wrinkled appearance, but apparently no minute spinules. The expansions are surrounded by a fairly thick chitinous integument, quite firm

* I am indebted to Dr. W. T. Calman, of the British Museum, for obtaining photographs of Nicolet's plates for me.

and hard and rather difficult to cut through. On opening one I found it to be loosely filled with a soft white substance of a granular nature, showing no definite structure, but containing numerous globules of fat. In this Paterson's Inlet specimen the tubercles on the segments of the peræon are rather more developed and more acutely pointed, especially those near the sides, than in the Chatham Islands specimen.

The antennules (fig. 47) have the first joint about as long as the second and third together, the third being only about half the size of the second.

The antennæ are large and strong in the male (fig. 48), but not so greatly expanded as in *D. aucklandiæ* ; the whole antenna is scabrous, with minute spinules, and bears also some fine setæ, especially towards the distal part. In the female (fig. 49) the antenna is much more slender and does not differ very much from that of the female of *D. aucklandiæ*.

The mouth-parts are, on the whole, similar to those of *D. aucklandiæ*. In the right mandible (fig. 50) the accessory appendage ends in a crown of small pointed teeth of irregular size, and the hairy lappet at its base bears a haired bristle similar to the "penicil" situated between the lappet and the tuft of bristles representing the molar tubercle ; this tuft contains a large number of bristles varying in length, those towards the cutting-edge being the shortest. The left mandible (fig. 51) has four teeth in the outer cutting-edge and three in the accessory appendage, the other parts being the same as in the right. The lower lip (fig. 52) and the first maxilla (fig. 53) are similar to those of *D. aucklandiæ* ; in the second maxilla (fig. 54) the outer lobe is much narrower than the inner one. The terminal portion of the maxilliped is shown in fig. 55, and does not differ in any essential detail from that of *D. aucklandiæ*.

The legs (fig. 56) are similar to those of *D. aucklandiæ*, though slightly more slender ; they are all of about the same length, the posterior ones being only slightly longer than the anterior ; in all, the inner surface of the joints, especially of the ischium, merus, carpus, and propod, is thickly covered with a dense fringe of short fine setæ ; a few stout spinules are found on the different joints, as shown in the figures.

The pleopoda are, on the whole, similar to those of *D. aucklandiæ*, except that the exopod of the first pleopod (fig. 57) is not so much produced at its inner distal angle ; the endopod is fairly stout, more than twice as long as the exopod, and is channelled on the posterior surface. The male organ reaches as far as the exopod. In the second pleopod (fig. 58) the terminal portion of the endopod forms an extremely long styliform process, about three times as long as the exopod, and a groove extends along its anterior surface throughout about two-thirds of its length.

The uropod (fig. 59) is, on the whole, similar to that of *D. aucklandiæ*, and has been sufficiently described in the specific diagnosis.

General Remarks.

The animals described above present many points of interest, some of which have been already briefly mentioned. Considering the large size of most of them and their striking appearance, it is rather remarkable that they have not been more fully described before this, but some of them occur in localities not very accessible, and, as has been mentioned under *D. marina*, even when the locality is accessible enough it is not always possible to find the specimens.

One of the most striking features is the great sexual dimorphism exhibited apparently by all the species, and the varied forms that this takes; thus in *D. bucculenta* the male differs from the female in the possession of the extraordinary balloon-like expansions of the first segment of the peræon; in *D. aucklandiæ* by the much longer and more prominent blunt spines on the dorsal surface; in *D. echinata* and in *D. armata* by the longer spines arising from the segments of the peræon; these are extremely long in *D. echinata*, and the capriciousness of the differences is shown in the fact that, although these two species appear to be closely similar in most respects, *D. armata* has spines on the peræon and also on the third and fourth segments of the pleon, while *D. echinata* has them only on the peræon. In *D. acinosa* the sexual differences are of a similar nature, but not so well marked; in *D. marina* the male is unknown.

All the species are strictly sea-shore inhabitants, probably not extending much above high-water mark or beyond the reach of the spray from the sea; in accordance with this they are all branchial breathers, and show no sign of the adaptation for aerial respiration exhibited by most of the other terrestrial Isopoda. In this respect, as well as in many points of structure, they agree with the genera *Scyphax* and *Scyphoniscus*, and it is probable that their nearest affinities will be found to be with these two genera. *Scyphax* differs from *Deto* in the very large and well-developed eye with its rows of numerous ocelli, and *Scyphoniscus* in the peculiar structure of the end of the outer lobe of the first maxilla; probably in both cases, however, these are characters of comparatively recent origin, and do not indicate a difference sufficient to counterbalance the many points of similarity.

The most interesting point connected with the species of *Deto*, however, is their geographical distribution, and they add a good example to the cases already known of closely allied forms being found on widely separated shores in subantarctic regions. *D. bucculenta*, from South America, which seems to be quite identical with the species described as *Oniscus novæ-zealandiæ*, from New Zealand, emphasises the close relationship between the fauna of New Zealand and that of the southern part of South America, and is paralleled by the existence of the freshwater Isopod *Idotea lacustris* in New Zealand and its Subantarctic Islands, and also in South America at the Straits of Magellan, and by the occurrence of *Trichoniscus magellanicus* and species

closely allied, if not identical, in the Subantarctic Islands of New Zealand, in Tierra del Fuego, the Falkland Islands, and Marion Island. Numerous other examples of similar distribution among the Crustacea and in other groups will be found in my concluding article (1909 A) on the "Subantarctic Islands of New Zealand." The close connection of Australia, St. Paul's Island, and South Africa with one another, and with the other subantarctic lands is shown by the occurrence in these places of species of *Deto* closely allied to one another, and not differing very much from those in New Zealand and South America. Another striking example of the same kind of distribution has recently been afforded in the discovery by Mr. Keppel H. Barnard † in freshwater streams of Cape Colony of a species of *Phreatoicus*, a genus hitherto known only from the surface and subterranean freshwaters of Australia and New Zealand. Probably further exploration will result in the discovery of species of *Deto* and of *Phreatoicus* on other subantarctic lands from which they have not yet been recorded.

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EXPLANATION OF THE PLATES.

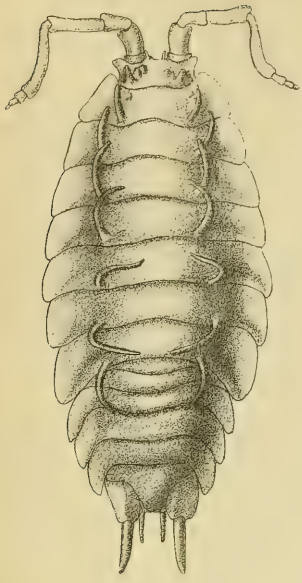
PLATE 39.

Fig. 1. *Deto echinata*, male, dorsal view. × 2½.
2. „ „ male, antennæ of same. × 8.
3. „ „ male, uropod of same. × 8.
4. *Deto acinosa*, male, dorsal view. × 4.
5. „ „ female, dorsal view. × 4.
6. „ „ antenna of male. × 12.
7. „ „ upper lip. × 12.
8. „ „ left mandible. × 60.
9. „ „ lower lip. × 30.
10. „ „ second maxilla. × 30.
11. „ „ maxilliped. × 30.

Fig. 12. *Deto acinosa*, first leg of male. × 20.
13. „ „ seventh leg of male. × 20.
14. „ „ first pleopod of male. × 20.
15. „ „ second pleopod of male. × 20.
16. „ „ first pleopod of female. × 30.
17. „ „ second pleopod of female. × 30.
18. „ „ uropod of male. × 20.
19. *Deto marina*, female, dorsal view. × 12.
20. „ „ antenna of same. × 25.
21. „ „ first leg of same. × 40.
22. „ „ seventh leg of same. × 40.
23. „ „ uropod. × 40.
24. *Deto aucklandiæ*, male, dorsal view. × 3.
25. „ „ female, dorsal view. × 3.
26. „ „ antennule of male. × 30.
27. „ „ antenna of male. × 8.
28. „ „ antenna of female. × 8.
29. „ „ right mandible of male. × 20.
30. „ „ end of left mandible of male. × 30.

Plate 40.

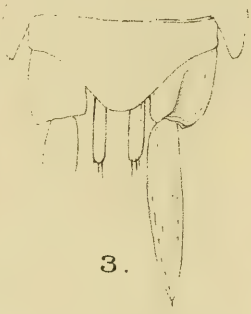
Fig. 31. *Deto aucklandiæ*, lower lip of male. × 12.
32. „ „ first maxilla of male. × 12.
33. „ „ second maxilla. × 12.
34. „ „ maxilliped. × 12.
35. „ „ maxilliped, extremity of same, more highly magnified.
36. „ „ first leg of male. × 8.
37. „ „ seventh leg of male. × 8.
38. „ „ first pleopod of male, seen from anterior side. × 12.
39. „ „ the same, from posterior side. × 12.
40. „ „ second pleopod of male. × 12.
41. „ „ fourth pleopod of male. × 12.
42. „ „ first pleopod of female. × 12.
43. „ „ second pleopod of female. × 12.
44. „ „ uropod of female, from below. × 8.
45. *Deto bucculenta*, male, dorsal view. × 7.
46. „ „ female. × about 5.
47. „ „ antennule of male. × 30.
48. „ „ antenna of male. × 12.
49. „ „ antenna of female. × 12.
50. „ „ right mandible of male. × 60.
51. „ „ left mandible of male. × 60.
52. „ „ lower lip. × 30.
53. „ „ first maxilla. × 30.
54. „ „ second maxilla. × 30.
55. „ „ end of maxilliped. × 30.
56. „ „ seventh leg of male. × 20.
57. „ „ first pleopod of male. × 20.
58. „ „ second pleopod of male. × 20.
59. „ „ uropod of male, from below. × 12.



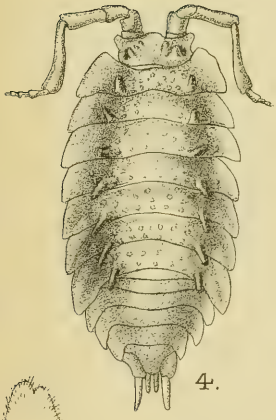
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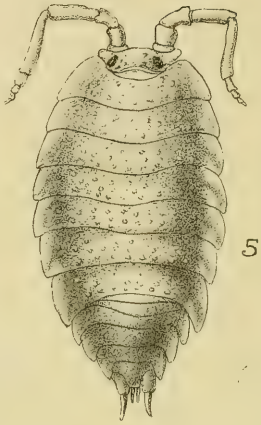
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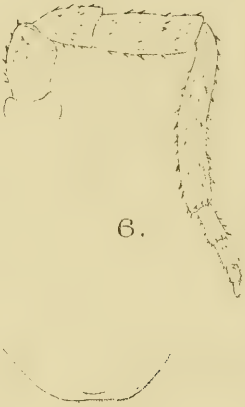
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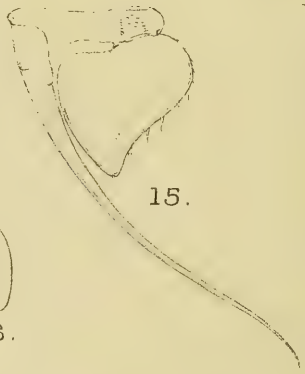
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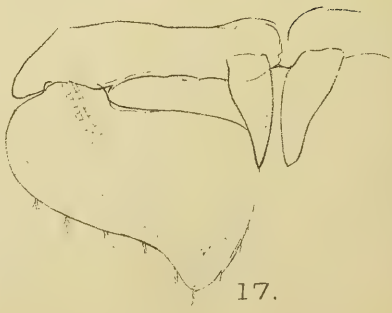
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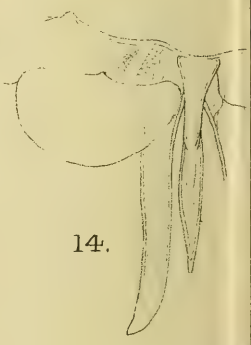


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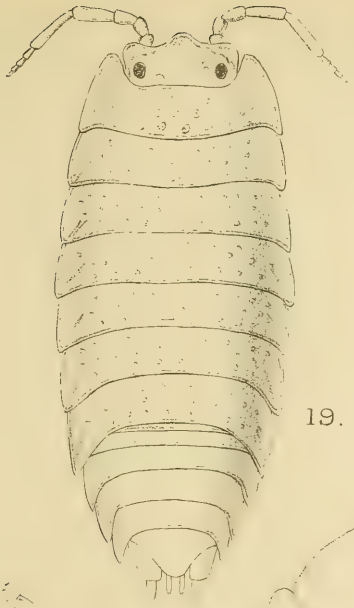




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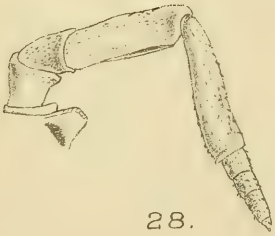
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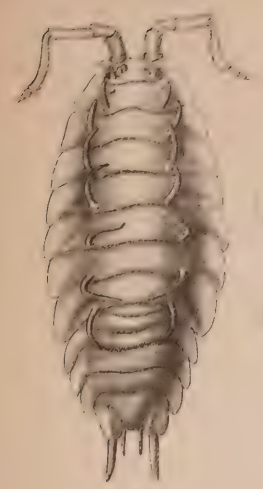
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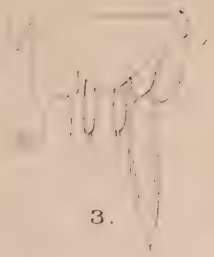
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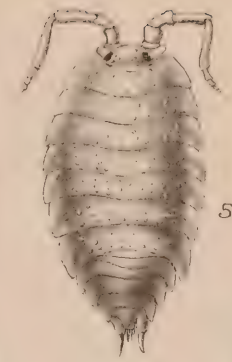
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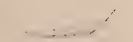
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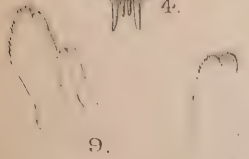
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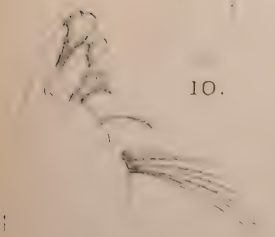
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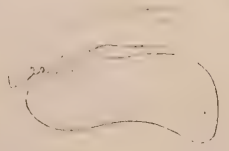
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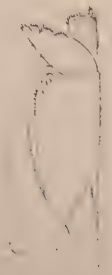
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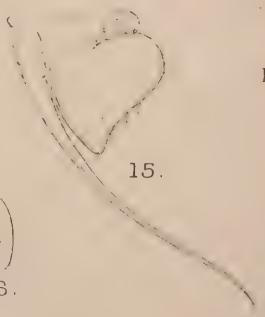
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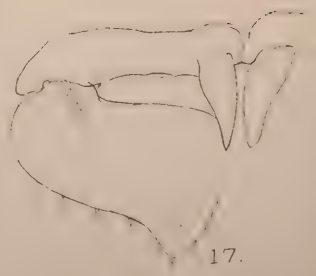
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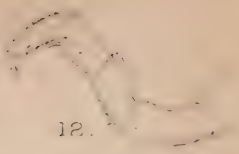
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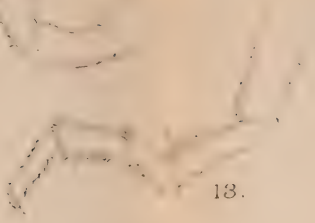
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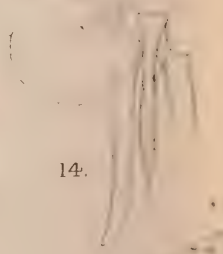
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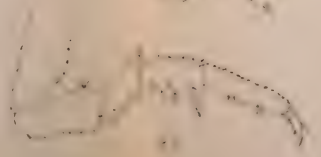


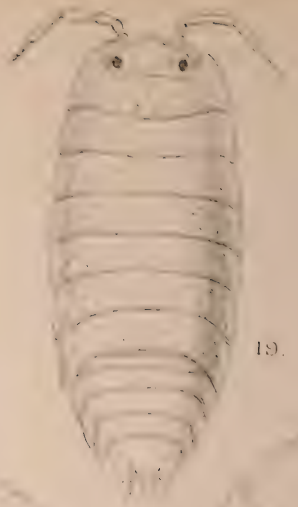
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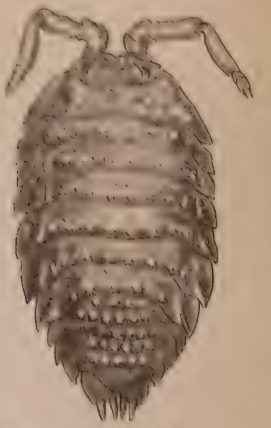
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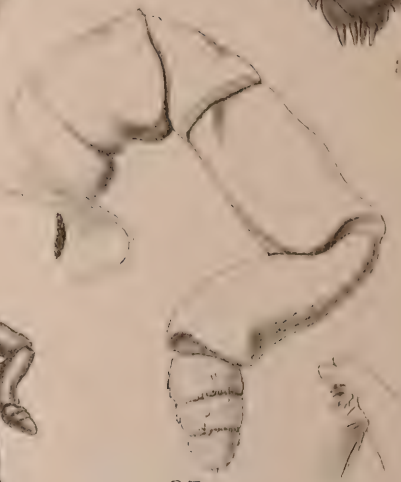
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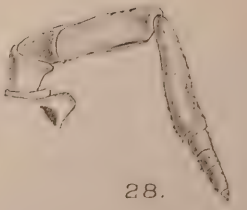
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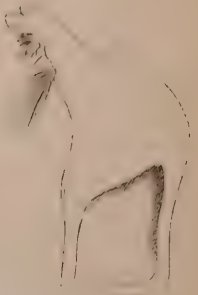
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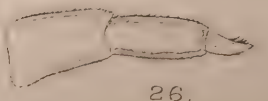
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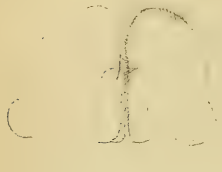
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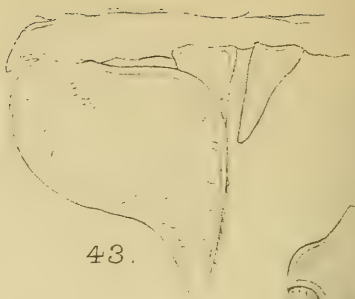
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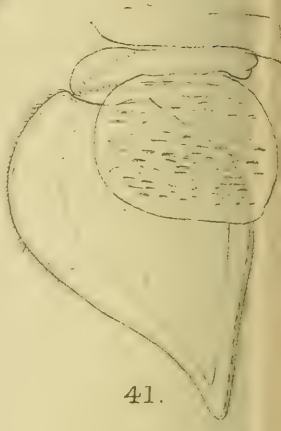
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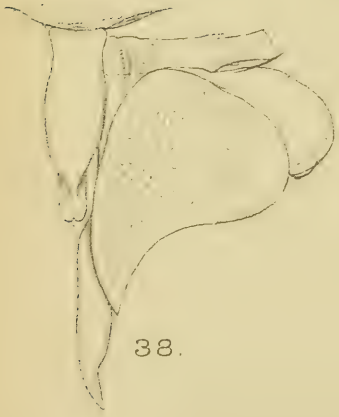
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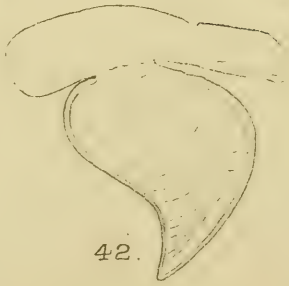
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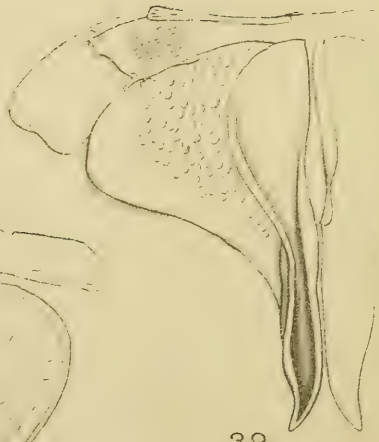
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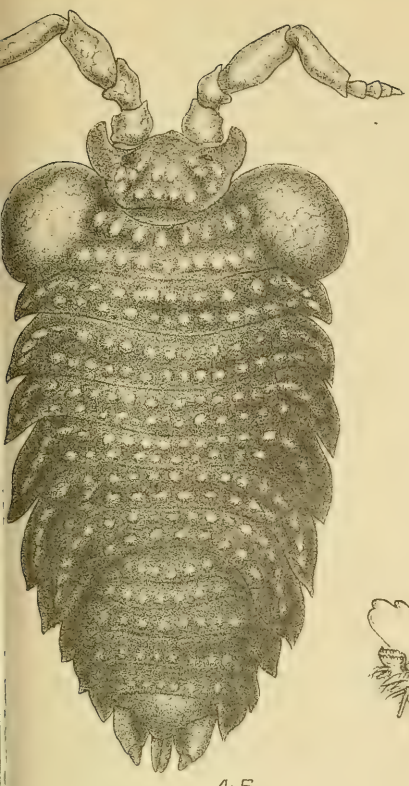


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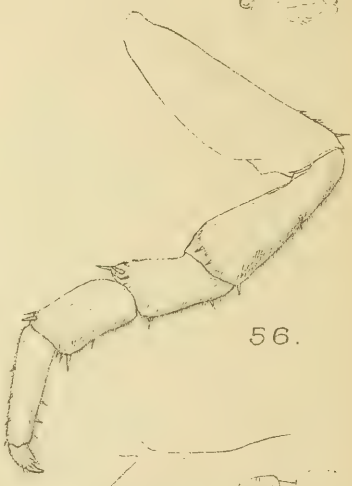
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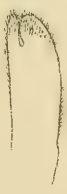
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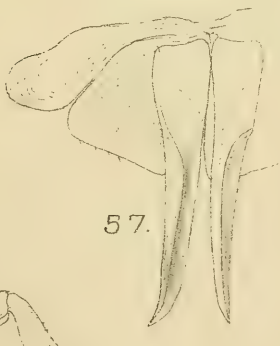
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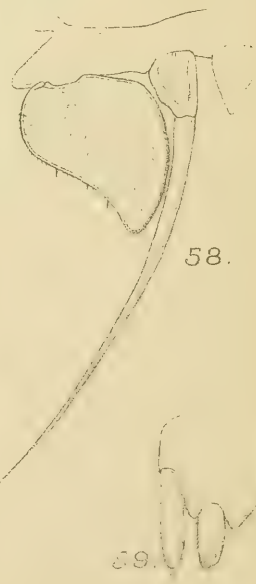
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THE JOURNAL

OF

THE LINNEAN SOCIETY.

VOL. XXXII. ZOOLOGY. No. 220.

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Results of Crossing two Hemipterous Species, with reference to the Inheritance of two Exclusively Male Characters.

By Katharine Foot and E. C. Strobell. (Communicated by Prof. E. B. Poulton, F.R.S., Pres.L.S.)

(Plates 41–47.)

[Read 3rd June, 1915.]

The results given in this paper are due to the interesting discovery made by Dr. Eltringham of Oxford, that there is a marked difference in the length of the intromittent organ of the two hemipterous species *Euschistus variolarius* and *Euschistus servus*.

We feel greatly indebted to Professor Poulton for kindly suggesting Dr. Eltringham to us, in response to our expressed wish to find an experienced entomologist in England who would be willing to study *E. variolarius* and *E. servus* with a view of discovering some marked character distinctive of each species that could be profitably studied in the hybrids.

The result of Dr. Eltringham's investigations is of special satisfaction to us, because the discovery of a difference in the length of the intromittent organ of the two species offers a valuable control for the results obtained and the conclusions we were able to draw from our study of the transmission of the genital spot *, enabling us to compare the inheritance of these two exclusively male characters *in the same insect*.

During our experimental work on the genital spot (Foot and Strobell, '13 & '14) we carefully isolated and preserved each insect, in the hope that future investigation by an experienced entomologist might reveal some other marked character in these insects that would enable us to determine what relation, if any, might exist between the inheritance of a second definite character and the inheritance of the genital spot in each hybrid.

Having our material preserved in this way has made it possible for us to demonstrate both the exact appearance of the genital spot and the exact length of the intromittent organ *in one and the same individual* of the F_1 and F_2 hybrids, and also of the offspring from the backcross. We have made this comparison very simple by placing the photographs of the intromittent organs demonstrated in this paper in exactly the same order in which the photographs of the insects themselves were placed in our paper on the

* This is a distinct black spot which is present on the genital segment of the males of *Euschistus variolarius*, and is a distinguishing feature of this species, while it is absent in *E. servus*. It is the presence of this exclusively male character which led us to cross these two species, with the hope of putting to an experimental test the chromosome-theory of sex-determination (Foot and Strobell, '13 & '14).

inheritance of the genital spot, which is published in this same volume (Plates 28–34). It is only necessary to compare the two sets of photographs in order to determine whether any definite relation exists in the inheritance of these two exclusively male characters. Such a comparison proves conclusively that the two are not linked in inheritance (see Linkage, p. 475).

The study of the genital spot in these hybrids (Foot and Strobell, '13 & '14) forced certain conclusions as to its bearing on recent chromosome-theories of heredity, and also its bearing on Mendel's law of heredity. We shall demonstrate in the following paper that the results obtained from the study of the genital spot are in fact duplicated in the case of the intromittent organ—the study of this second exclusively male character supporting *in every detail* the conclusions forced by the facts of inheritance of the genital spot.

Results and Discussion.

We have dissected the intromittent organs from the genital segment of many of the parent species and from all the hybrids both of the F_1 and F_2 generations, and also from the offspring of the backcross. After mounting, the intromittent organs were photographed at a magnification of 20 diameters, and all the measurements were carefully made from these photographs; therefore all the recorded lengths of the intromittent organs must be reduced to one-twentieth to obtain the actual lengths.

The intromittent organ of *Euschistus variolarius* (at a magnification of 20 diameters) varies in length between 85·5 mm. and 106 mm., while that of *Euschistus servus* varies between 146 mm. and 182 mm. These measurements were made from 62 pure *variolarius* specimens, and from 62 pure *servus* specimens.

The following tables give the measurements of the photographs of the intromittent organs (arranged in order of length) of the parent species, of hybrids, and of the backcross.

Table 1 gives the lengths of the intromittent organs from 62 specimens of *Euschistus variolarius*, and shows those cases in which 2 or more specimens have the same length.

Table 2 gives the lengths of the 62 intromittent organs from *Euschistus servus*.

Tables 3 to 11 show the lengths of the intromittent organs from all the F_2 hybrids and from the offspring of the backcross. These tables also show to what degree the genital spot is inherited by each hybrid, and they therefore demonstrate what relation, if any, exists in the inheritance of these two exclusively male characters. Tables 3 to 9 inclusive give the lengths of the intromittent organs for each family of the 7 pairs of F_1 hybrids; and the mean length of the intromittent organ is computed for each separate family as well as for the total number of F_2 hybrids.

TABLE 1.

Lengths of intromittent organs from 62 specimens of *Euschistus variolarius*. × 20 diams.

85½ mm.	1
87 mm.	1
88 mm.	1
89 mm.	1
90 mm.	1
91 mm.	1
92 mm.	2
93 mm.	4
93½ mm.	1
94 mm.	6
94½ mm.	2
95 mm.	1
95½ mm.	2
96 mm.	7
96½ mm.	1
97 mm.	1
97½ mm.	1
98 mm.	6
98½ mm.	1
99 mm.	2
100 mm.	7
100½ mm.	1
101 mm.	4
102 mm.	3
104 mm.	1
104½ mm.	2
106 mm.	1
5,996	62

Mean length = 96·70 mm.

TABLE 2.

Lengths of intromittent organs from 62 specimens of *Euschistus servus*. × 20 diams.

146 mm.	1
152 mm.	1
154 mm.	1
158 mm.	2
158½ mm.	1
160 mm.	1
160½ mm.	2
161 mm.	1
162 mm.	4
162½ mm.	3
163½ mm.	2
164 mm.	4
164½ mm.	2
165 mm.	1
165½ mm.	1
166 mm.	8
166½ mm.	1
167 mm.	3
167½ mm.	1
168 mm.	1
169 mm.	1
169½ mm.	1
170 mm.	4
170½ mm.	1
171 mm.	1
172 mm.	1
172½ mm.	1
173 mm.	2
174 mm.	1
174½ mm.	1
175 mm.	1
175½ mm.	1
176 mm.	1
176½ mm.	1
177 mm.	1
179½ mm.	1
182 mm.	1
10,318	62

Mean length = 166·41 mm.

Tables 3 to 10.

Lengths of the intromittent organs in the F_2 hybrids, showing the influence of the two original parent species, and a comparison of these lengths with the inheritance of the *E. variolarius* genital spot. This comparison demonstrates that these two exclusively male characters are not linked in inheritance.

Table 3.—F_2 males from the 1st pair of F_1 hybrids. Plate 42. 43 specimens.

Photos.	*Genital spot.**	*Intromittent organ.* × 20 diams.
17	1st (upper) bug intermediate.	*E. variolarius* 96 mm.
	2nd „ ditto.	*E. servus* 146 „
	3rd „ ditto.	Intermediate 130 „
	4th „ *E. servus.*	ditto 136 „
	5th „ intermediate.	*E. servus* 150 „
18	1st (upper) bug intermediate.	Intermediate 112½ mm.
	2nd „ ditto.	ditto 128 „
	3rd „ ditto.	ditto 122 „
	4th „ ditto.	ditto 137 „
	5th „ *E. servus.*	*E. servus* 148 „
19	1st (upper) bug intermediate.	Intermediate 114 mm.
	2nd „ ditto.	ditto 129 „
	3rd „ *E. servus.*	ditto 139½ „
	4th „ ditto.	ditto 144 „
20	1st (upper) bug *E. servus.*	Intermediate 130 mm.
	2nd „ ditto.	ditto 120 „
	3rd „ ditto.	*E. variolarius* 98 „
21	1st (upper) bug intermediate.	Intermediate 124 mm.
	2nd „ *E. servus.*	*E. servus* 152 „
	3rd „ ditto.	Intermediate 133 „
	4th „ ditto.	ditto 122 „
	5th „ ditto.	ditto 136 „
	6th „ ditto.	*E. variolarius* 97 „
22	1st (upper) bug *E. servus.*	Intermediate 136 mm.
	2nd „ ditto.	*E. servus* 146 „
	3rd „ ditto.	Intermediate 124 „
	4th „ ditto.	ditto 128½ „
	5th „ ditto.	ditto 130 „
23	1st (upper) bug *E. variolarius.*	*E. variolarius* 98 mm.
	2nd „ *E. servus.*	Intermediate 120 „
	3rd „ ditto.	*E. variolarius* 104 „
	4th „ ditto.	Intermediate 122 „

* The genital segment of these insects is demonstrated in Plates 28–34 of this volume, the number of the photographs being the same for the two papers, thus admitting an accurate comparison of the inheritance of the genital spot and the type of intromittent organ. In classifying the photographs of these hybrids we included under the *servus* type not only those specimens with no spot whatever, but also those with merely a faint indication of a spot, for the latter was not visible in the living specimens nor in those freshly killed. Such a faint indication of a spot will probably not show in all the prints.

Photos.	*Genital spot.*	*Intromittent organ.* × 20 diams.
24	1st (upper) bug intermediate.	*E. variolarius* 100 mm.
	2nd „ *E. servus.*	Intermediate 114 „
	3rd „ ditto.	ditto 132½ „
25	1st (upper) bug intermediate.	Intermediate 114½ mm.
	2nd „ ditto.	ditto 123 „
	3rd „ ditto.	*E. variolarius* 100 „
	4th „ ditto.	Intermediate 108 „
	5th „ ditto.	*E. variolarius* 93 „
	6th „ *E. servus.*	Intermediate 132 „
	7th „ ditto.	*E. variolarius* 85½ „
	8th „ ditto.	Intermediate 140 „

Mean length of intromittent organ, 123·14 mm.

TABLE 4.—F_2 males from the second pair of F_1 hybrids. Plate 43.
30 specimens.

Photos.	*Genital spot.*	*Intromittent organ.* × 20 diams.
26	1st (upper) bug *E. variolarius.*	Intermediate 115½ mm.
	2nd „ intermediate.	*E. variolarius* 100 „
	3rd „ ditto.	Intermediate 116 „
	4th „ ditto.	ditto 118 „
	5th „ ditto.	ditto 118 „
27	1st (upper) bug intermediate.	*E. variolarius* 99 mm.
	2nd „ *E. servus.*	Intermediate 130 „
	3rd „ ditto.	ditto 130 „
	4th „ ditto.	ditto 130 „
28	1st (upper) bug *E. variolarius.*	*E. variolarius* 90 mm.
	2nd „ intermediate.	Intermediate 142 „
	3rd „ *E. servus.*	ditto 124 „
	4th „ ditto.	ditto 131 „
	5th „ intermediate.	ditto 121 „
	6th „ *E. servus.*	ditto 127½ „
29	1st (upper) bug *E. servus.*	Intermediate 124 mm.
	2nd „ ditto.	ditto 123 „
	3rd „ ditto.	ditto 125 „
	4th „ intermediate.	ditto 126 „
	5th „ *E. servus.*	ditto 126 „
30	1st (upper) bug *E. servus.*	Intermediate 130 mm.
	2nd „ ditto.	ditto 134½ „
	3rd „ ditto.	ditto 115½ „
	4th „ ditto.	ditto 133 „
31	1st (upper) bug intermediate.	Intermediate 114 mm.
	2nd „ ditto.	ditto 114 „
	3rd „ ditto.	*E. variolarius* 99½ „
32	1st (upper) bug *E. variolarius.*	Intermediate 114½ mm.
	2nd „ intermediate.	ditto 122 „
	3rd „ *E. servus.*	ditto 127 „

Mean length of intromittent organ, 120·67 mm.

TABLE 5.—F_2 males from the third pair of F_1 hybrids. Plate 44. 48 specimens.

Photos.		*Genital spot.*	*Intromittent organ.* × 20 diams.
33	1st (upper) bug	intermediate.	Intermediate $117\frac{1}{2}$ mm.
	2nd „	ditto.	ditto 124 „
	3rd „	ditto.	ditto $116\frac{1}{2}$ „
	4th „	ditto.	ditto 144 „
	5th „	*E. servus.*	ditto $123\frac{1}{2}$ „
	6th „	intermediate.	ditto 130 „
34	1st (upper) bug	*E. variolarius.*	Intermediate 128 mm.
	2nd „	intermediate.	ditto 131 „
	3rd „	ditto.	ditto 140 „
	4th „	*E. servus.*	ditto 130 „
	5th „	*E. variolarius.*	ditto 140 „
	6th „	ditto.	ditto 121 „
	7th „	intermediate.	ditto 123 „
	8th „	ditto.	*E. servus* 147 „
35	1st (upper) bug	*E. variolarius.*	*E. variolarius* 104 mm.
	2nd „	ditto.	Intermediate 115 „
	3rd „	intermediate.	ditto 126 „
	4th „	ditto.	ditto 134 „
	5th „	*E. servus.*	ditto $134\frac{1}{2}$ „
36	1st (upper) bug	*E. variolarius.*	Intermediate 114 mm.
	2nd „	intermediate.	ditto $127\frac{1}{2}$ „
	3rd „	ditto.	ditto $127\frac{1}{2}$ „
	4th „	*E. servus.*	ditto 124 „
	5th „	ditto.	ditto 142 „
	6th „	ditto.	ditto 120 „
	7th „	ditto.	ditto $127\frac{1}{2}$ „
37	1st (upper) bug	*E. servus.*	Intermediate $122\frac{1}{2}$ mm.
	2nd „	intermediate.	ditto $122\frac{1}{2}$ „
	3rd „	*E. servus.*	ditto 126 „
38	1st (upper) bug	intermediate.	Intermediate 112 mm.
	2nd „	ditto.	ditto 120 „
	3rd „	ditto.	ditto 126 „
	4th „	*E. servus.*	ditto $139\frac{1}{2}$ „
	5th „	ditto.	ditto 140 „
39	1st (upper) bug	intermediate.	Intermediate 137 mm.
	2nd „	ditto.	ditto $134\frac{1}{2}$ „
	3rd „	*E. servus.*	ditto 140 „
	4th „	ditto.	ditto 124 „
40	1st (upper) bug	*E. variolarius.*	Intermediate $114\frac{1}{2}$ mm.
	2nd „	intermediate.	ditto 117 „
	3rd „	ditto.	ditto 122 „
	4th „	ditto.	ditto $136\frac{1}{2}$ „
	5th „	ditto.	ditto 126 „
	6th „	ditto.	ditto $126\frac{1}{2}$ „
	7th „	ditto.	ditto 120 „
41	1st (upper) bug	*E. variolarius.*	Intermediate $116\frac{1}{2}$ mm.
	2nd „	intermediate.	ditto 132 „
	3rd „	ditto.	ditto 126 „

Mean length of intromittent organ, 126·92 mm.

TABLE 6.—F_2 males from the fourth pair of F_1 hybrids. Plate **45**.
27 specimens.

Photos.	*Genital spot.*	*Intromittent organ.* × 20 diams.
42	1st (upper) bug intermediate.	Intermediate 142 mm.
	2nd „ ditto.	ditto 130 „
	3rd „ ditto.	ditto 130½ „
	4th „ *E. servus.*	ditto 136 „
43	1st (upper) bug intermediate.	Intermediate 118½ mm.
	2nd „ ditto.	ditto 132 „
	3rd „ ditto.	ditto 140 „
	4th „ *E. servus.*	ditto 133 „
	5th „ ditto.	ditto 127 „
	6th „ ditto.	ditto 138 „
	7th „ ditto.	ditto 141½ „
44	1st (upper) bug intermediate.	Intermediate 115 mm.
	2nd „ ditto.	ditto 127 „
45	1st (upper) bug intermediate.	Intermediate 128 mm.
	2nd „ ditto.	ditto 136 „
	3rd „ ditto.	ditto 137 „
46	1st (upper) bug *E. variolarius.*	Intermediate 116½ mm.
	2nd „ intermediate.	ditto 128 „
	3rd „ *E. variolarius.*	ditto 122 „
	4th „ ditto.	ditto 120 „
	5th „ intermediate.	ditto 136 „
	6th „ ditto.	ditto 127 „
47	1st (upper) bug intermediate.	Intermediate 119½ mm.
	2nd „ ditto.	ditto 110 „
	3rd „ ditto.	ditto 142 „
	4th „ ditto.	ditto 121 „
48	*E. variolarius.*	Intermediate 110 mm.

Mean length of intromittent organ, 128·27 mm.

TABLE 7.—F_2 males from the fifth pair of F_1 hybrids. (4 specimens.)
Photos 15–16, Plate **41**.

Photos.	*Genital spot.*	*Intromittent organ.* ×20 diams.
15	1st (upper) bug *E. variolarius.*	Intermediate 108 mm.
	2nd „ intermediate.	ditto 107½ „
	3rd „ ditto.	*E. servus* 147 „
16	*E. servus.*	Intermediate 135 mm.

Mean length of intromittent organ, 124·37 mm.

TABLE 8.—F_2 males from the sixth pair of F_1 hybrids. (6 specimens.)
Photos 49–50, Plate **45**.

Photos.	*Genital spot.*	*Intromittent organ.* ×20 diams.
49	1st (upper) bug intermediate.	Intermediate 113½ mm.
	2nd „ *E. servus.*	ditto 129½ „
50	1st (upper) bug intermediate.	Intermediate 128 mm.
	2nd „ ditto.	ditto 128 „
	3rd „ ditto.	ditto 125 „
	4th „ ditto.	ditto 134 „

Mean length of intromittent organ, 126·33 mm.

TABLE 9.—F_2 males from the seventh pair of F_1 hybrids. Plate **46**.
(32 specimens.)

Photos.	*Genital spot.*	*Intromittent organ.* ×20 diams.
51	1st (upper) bug intermediate.	Intermediate 110 mm.
	2nd „ *E. servus.*	ditto 120 „
	3rd „ ditto.	ditto 131 „
	4th „ intermediate.	ditto 119 „
	5th „ *E. servus.*	ditto 136½ „
	6th „ ditto.	ditto 121½ „
	7th „ ditto.	ditto 138 „
	8th „ ditto.	ditto 115 „
	9th „ intermediate.	ditto 122 „
52	1st (upper) bug *E. servus.*	Intermediate 127 mm.
	2nd „ intermediate.	ditto 123½ „
	3rd „ ditto.	ditto 112 „
	4th „ *E. servus.*	ditto 128 „
	5th „ ditto.	ditto 120 „
	6th „ ditto.	ditto 136 „
53	1st (upper) bug intermediate.	Intermediate 115½ mm.
	2nd „ ditto.	ditto 112 „
	3rd „ ditto.	ditto 115 „
	4th „ *E. servus.*	ditto 143½ „
54	1st (upper) bug intermediate.	Intermediate 130 mm.
	2nd „ ditto.	ditto 120 „
	3rd „ *E. servus.*	ditto 135 „
	4th „ intermediate.	ditto 112 „
55	1st (upper) bug *E. variolarius.*	Intermediate 116½ mm.
	2nd „ intermediate.	ditto 118 „
	3rd „ ditto.	ditto 118 „
	4th „ *E. servus.*	ditto 131 „
56	1st (upper) bug *E. variolarius.*	Intermediate 112½ mm.
	2nd „ intermediate.	ditto 119 „
	3rd „ *E. servus.*	ditto 129½ „
57	1st (upper) bug intermediate.	Intermediate 106½ mm.
	2nd „ ditto.	ditto 120 „

Mean length of intromittent organ, 122·29 mm.

TABLE 10.—Summary of the above detailed results.

	No. of specimens with *E. variolarius* genital spot.	No. of specimens with *E. variolarius* length of intromittent organ. (Between 85½ mm. and 106 mm.)	No. of specimens without genital spot (like *E. servus*).	No. of specimens with *E. servus* length of intromittent organ. (Between 146 mm. and 182 mm.)	No. of specimens with genital spot intermediate between *E. variolarius* and *E. servus*.	No. of specimens with length of intromittent organ intermediate between *E. variolarius* and *E. servus*.
F_2 males from 1st pair of F_1 hybrids (43 specimens). Photos 17–25.	1	9	25	5	17	29
F_2 males from 2nd pair of F_1 hybrids (30 specimens). Photos 26–32.	3	4	15	0	12	26
F_2 males from 3rd pair of F_1 hybrids (48 specimens). Photos 33–41.	8	1	13	1	27	46
F_2 males from 4th pair of F_1 hybrids (27 specimens). Photos 42–48.	4	0	5	0	18	27
F_2 males from 5th pair of F_1 hybrids (4 specimens). Photos 15–16.	1	0	1	1	2	3
F_2 males from 6th pair of F_1 hybrids (6 specimens). Photos 49–50.	0	0	1	0	5	6
F_2 males from 7th pair of F_1 hybrids (32 specimens). Photos 51–57.	2	0	14	0	16	32
TOTALS	19	14	74	7	97	169

Mean length of intromittent organ of the 190 F_2 hybrids, 124·42 mm.

TABLE 11.—Lengths of the intromittent organs in the 18 males from the Backcross (*i. e.* F_1 ♀ × pure *variolarius* ♂), side by side with the inheritance of the *E. variolarius* genital spot. A comparison demonstrates again that these two exclusively male characters are not linked in inheritance. Photos 62–66, Plate 47.

Photos.	*Genital spot.*	*Intromittent organ.* × 20 diams.
62	1st (upper) bug *E. variolarius.*	Intermediate 112½ mm.
	2nd „ ditto.	*E. variolarius* 105 „
	3rd „ intermediate.	Intermediate 128½ „
	4th „ ditto.	ditto 117 „
63	1st (upper) bug *E. variolarius.*	Intermediate 110½ mm.
	2nd „ ditto.	ditto 116 „
	3rd „ ditto.	*E. variolarius* 106 „
	4th „ ditto.	Intermediate 107 „
64	1st (upper) bug *E. variolarius.*	Intermediate 115 mm.
	2nd „ ditto.	ditto 112½ „
	3rd „ intermediate.	ditto 122½ „
	4th „ *E. variolarius.*	*E. variolarius* 102 „
	5th „ intermediate.	Intermediate 119 „
	6th „ *E. variolarius.*	ditto 118 „
65	*E. variolarius.*	Intermediate 113½ mm.
66	1st (upper) bug *E. variolarius.*	Intermediate 114½ mm.
	2nd „ intermediate.	ditto 116½ „
	3rd „ ditto.	ditto 106½ „

Mean length of intromittent organ, 113·47 mm.

It is an interesting fact that Mendel's Law of Heredity owed its inception in part to an analytical study of a size-character—the character which has proved on further investigation to be the greatest stumbling-block to an unqualified acceptance of the law as a wholly satisfactory explanation of the problems of heredity. In his original work on tall and dwarf peas, Mendel found that two lengths so far apart as 6 ft. and 1½ ft. acted as unit characters, and these characters showed dominance and segregation.

More recent work on size-relations has led to an accumulation of facts showing that in the majority of cases dominance and segregation in the Mendelian ratios of 1–2–1 are not present; and many Mendelians have made ingenious efforts to reconcile these facts with their conception of Mendelism by adding a superstructure to Mendel's original law, which has called forth an earnest protest from certain investigators.

Castle was the first Mendelian to demonstrate a case in which dominance and segregation were found to be absent where a length-character was carefully studied. He crossed the long-eared lop rabbit with the ordinary short-eared type, and found the F_1 generation with ears intermediate in

length, and no Mendelian segregation in the F_2 generation. These facts, together with further studies on size-relations, followed by his striking results in selection (Castle, '12 & '14), have led him to question certain hypotheses which he believes are quite unnecessary adjuncts to Mendelism.

As Castle believes that both small and large variations are inherited, he questions the mutation theory which claims "that only variations of some size are inherited".

As he believes in quantitative variations of unit characters, he questions the multiple factor hypothesis.

As he has demonstrated that quantitative variations can be increased by selection, he questions the hypothesis which denies this possibility (genotype theory).

Of unit characters he says: "In my experience *every* unit character is subject to quantitative variation, that is, its expression in the body varies, and it is clear that these variations have a germinal basis because they are inherited."

"It is the substantial integrity of a quantitative variation from cell-generation to cell-generation that constitutes the basis of Mendelism. All else is imaginary." (Castle, '12 *a*.)

Castle has arrived at his present conception of Mendelism through his extended and thoroughly scientific experiments on quantitative variations; and the results of his experimental studies of size-differences appear to be so completely in harmony with the results of our cross-breeding experiments with *Euschistus*, that we shall give a brief summary of his observations before we present the facts which seem to us to support them.

His wide experience in experimental breeding in relation to size-characters entitles him to speak with authority on this subject.

His observations may be briefly stated as follows:—

First. Dominance is absent in the F_1 hybrid generation.
Second. The F_1 hybrids are intermediate in size.
Third. Mendelian segregation is absent in the F_2 hybrid generation.
Fourth. There is increased variability in the F_2 generation as compared with the F_1 generation.
Fifth. The F_2 generation, like the F_1, is intermediate in size.
Sixth. Both extremes in size of the original parents may be found in the F_2 generation, but not in the F_1 generation.
Seventh. Size-characters, in common with all characters (even those that Mendelize), show quantitative variation.

We shall compare these observations with our own results, and when making this comparison we shall consider first the intromittent organ, and then the genital spot, in order to point out that the results from these two exclusively male characters are identical.

"First. *Dominance is absent in the F_1 hybrid generation.*"—This is supported by our measurements of the intromittent organ; for not one of the ten * F_1 hybrids has a length of intromittent organ that comes within the range characteristic of either *variolarius* or of *servus*. They are all intermediate: one measures 109 mm., one 122 mm., two 124 mm., four 126 mm., one 132 mm., and one 134 mm.†

Absence of dominance is equally evident in the case of the genital spot; for nine of the eleven F_1 hybrids are variable intermediates, while only two are like one of the parent species—*i. e.*, like *servus* in having no spot.

"Second. *The F_1 hybrids are intermediate in size.*"—This is quite true for both the intromittent organ and the genital spot, though it can be more clearly demonstrated in the former.

The mean length of the intromittent organ of *Euschistus variolarius* is 96·70 mm. (Table 1), and that of *E. servus* is 166·41 mm. (Table 2). A precise intermediate between these two means would be 131·55 mm. (*i. e.*, 34·85 mm. above the mean of *E. variolarius* or below the mean of *E. servus*).

The mean length of the organ in the F_1 hybrids computed from the ten specimens is 124·9 mm., which is slightly below the precise intermediate (131·55 mm.), and shows therefore a stronger inheritance from *E. variolarius* than from *E. servus*. The exact length of each specimen, as stated above, shows the F_1 intromittent organs to be *very variable* intermediates, ranging between 109 mm. and 134 mm. in length.

In the case of the genital spot the slightly stronger inheritance is from *E. servus* instead of from *E. variolarius*, for two of the eleven hybrids are like *servus* in having no spot. The remaining nine specimens are variable intermediates (photos 8 to 14, Plate 28 of this volume), and therefore the genital spot as well as the intromittent organ may be said to be approximately intermediate in size between the two parent species.

"Third. *Mendelian segregation is absent in the F_2 hybrid generation.*"—In our study of the transmission of the genital spot of *variolarius* (Foot and Strobell, '14 *a*) we divided the hybrids into three groups—those having a genital spot like those of pure *variolarius*, those without a spot like *servus*, and those with a spot intermediate between these two extremes. In the case of the intromittent organ we have grouped the hybrids into three similar classes—those having a length of intromittent organ within the range of that of *variolarius*, those with a length of organ within the range of that of *servus*, and those with a length intermediate between the longest found in *variolarius* and the shortest found in *servus*.

If we are looking for a simple Mendelian segregation of 1–2–1 and assume that the heterozygotes are represented by the intermediates, we should

* The intromittent organ of the eleventh F_1 hybrid was destroyed in dissection.

† These lengths are given in connection with each photograph (7 to 14), and can therefore be compared with the inheritance of the genital spot.

expect to find these two exclusively male characters in the F_2 hybrids in the following ratio :—25 % like *variolarius*, 25 % like *servus*, and 50 % intermediates. We ought to find 47 of the 190 F_2 hybrids like *variolarius*, 47 like *servus*, and 94 intermediates ; whereas we find in the case of the intromittent organ 14 like *variolarius*, 7 like *servus*, and 169 intermediates (see Table 10), and in the case of the genital spot 19 like *variolarius*, 74 like *servus*, and 97 intermediates (Table 10). Both characters—the intromittent organ and the genital spot—are therefore like other size-characters in their failure to show Mendelian segregation in the F_2 generation.

"Fourth.—*There is increased variability in the F_2 generation as compared with the F_1 generation.*"—This appears at first sight to be true both for the intromittent organ and for the genital spot, but the evidence is unsatisfactory in that the number of individuals is so very different for the two generations, and, as variation is present in both generations, we must expect the larger number to give the larger number of variations. We have the exact length of the intromittent organ for 190 specimens of the F_2 generation, but have it for only 10 of the F_1 generation. There are 69 variations of length in the 190 F_2 hybrids (Tables 3 to 9), and only six variations in the ten F_1 hybrids. The latter, however, represents more variations in relation to the number of specimens than the 69 variations in the 190 F_2 hybrids.

These relations hold true also in the case of the genital spot, though the evidence here is not so exact, as the differences cannot be accurately measured as in the case of the intromittent organ.

On the whole we are not justified in claiming that the evidence is in accord with the observations on those size-characters which show that "there is increased variability in the F_2 generation as compared to the F_1 generation".

"Fifth. *The F_2 generation, like the F_1, is intermediate in size.*"—This point can again be most satisfactorily demonstrated in the case of the intromittent organ, for we know the mean length of the organ for both parent species, for the F_1 generation, the F_2 generation, and for the seven separate families of these F_2 hybrids.

As stated above, the theoretically precise intermediate between the mean lengths of the two parent species would be 131·55 mm.

The following are the mean lengths of intromittent organ of the F_2 males from the seven pairs of F_1 hybrids :—

1st pair of F_1 hybrids.....	123·14 mm. (table 3).
2nd pair of F_1 hybrids.....	120·67 mm. (table 4).
3rd pair of F_1 hybrids	126·92 mm. (table 5).
4th pair of F_1 hybrids	128·27 mm. (table 6).
5th pair of F_1 hybrids	124·37 mm. (table 7).
6th pair of F_1 hybrids	126·33 mm. (table 8).
7th pair of F_1 hybrids	122·29 mm. (table 9).

The mean length of the intromittent organ computed from the total number of F_2 males (190 specimens) is 124·42 mm. A comparison of this with the mean length of the organ of the F_1 hybrids (124·9 mm.) shows that the mean length is almost the same for both the first and second generations, differing only by a few hundredths of a millimetre. It is clear therefore that the F_2 generation, like the F_1, is intermediate in size, and both agree further in showing a stronger inheritance from *variolarius* than from *servus*. This is true not only when the total number of F_2 hybrids is considered, but holds for each individual family of the F_2 generation—each of the seven families has a mean length of intromittent organ which is below the theoretical intermediate between the parent species (131·55 mm.).

" Sixth. *Both extremes in size of the original parents may be found in the F_2 generation, but not in the F_1 generation.*"—As the two characters we are testing are exclusively male, we can compare our results with the above observation only in the case of the original male parent. The length of the intromittent organ of the original *E. servus* male parent of the first cross is 166 mm., a length which has not been reached in any of the 190 specimens of the F_2 generation, the longest intromittent organ of all these F_2 hybrids measuring only 152 mm. (Table 3), and in only one specimen of the 190 was this length attained. We therefore cannot say that the length of the intromittent organ of this grandparent is found in our F_2 generation. If we disregard this length and take into consideration the *mean length* of the organ both in *servus* and in *variolarius*, we then find that a length of intromittent organ characteristic of both species is represented in the F_2 generation, and we find a still larger number like the two species, if we consider all the F_2 hybrids which have a length of organ within the limits of length characteristic of *variolarius* and *servus*. For example, 14 F_2 hybrids are like *variolarius* in having the length of intromittent organ 106 mm. or less, and 7 are like *servus* in having the length of intromittent organ 146 mm. or more (Tables 3 to 10).

Among the ten F_1 hybrids we find none with a length of organ like *E. variolarius* (106 mm. or less) nor any like *E. servus* (146 mm. or more), but we are inclined to believe that this is due to the relatively small number of specimens. As stated above, the relative number of variations in length of the intromittent organ of the ten F_1 hybrids is greater than that of the F_2 generation, and therefore we should expect a larger number of specimens to give us a larger range of variation. Even among these ten specimens we have one with the intromittent organ only 109 mm. long, and this is within 3 mm. of the *variolarius* type.

The results in the case of the genital spot are very similar. Nine of the eleven F_1 hybrids have a spot variably intermediate between that of the two parent species, but two are like *servus* in having no spot.

In the F_2 generation the extremes of the genital spot (*i. e.*, its full size and its complete absence) are represented, 19 of the F_2 hybrids having a genital spot almost if not quite as pronounced as the pure *variolarius* species, and 74 having no spot like *E. servus*.

"Seventh. *Size-characters, in common with all characters (even those that Mendelize), show quantitative variation.*"—Quantitative variation is of course more accurately demonstrated in the case of the intromittent organ than in the genital spot, though it is present in both these characters. Table 1 shows that in 62 specimens of *E. variolarius* the length of the organ varied between 85½ mm. and 106 mm., the range of the variation between the shortest and the longest being 20·5 mm. The table gives the number of specimens having the various lengths, and it demonstrates that there is no definite ascending or descending scale of variation in relation to the number of specimens having a given length of the organ, though the extremes are represented by only one specimen, and lengths near the mean are more frequently represented.

This is true also for *E. servus* as demonstrated in Table 2. This table gives the lengths of the intromittent organs for 62 specimens, and shows that this length varies between 146 mm. and 182 mm., the range of the variation between the shortest and the longest being therefore 36 mm.

Variations in the length of the intromittent organ may be quite independent of the relative size of the insects, not only in the hybrid generations, but also in the pure species: for example, the photographs of the two intromittent organs shown in photo 6 measure 104 mm. and 94 mm. The two insects from which these organs were taken are brothers of the *E. variolarius* female of the original cross. The one having the longer intromittent organ (104 mm.) is decidedly the smaller insect, the actual width of the pronotum (between the humeri) being 8½ mm., while the pronotum of the insect with the shorter organ measured 9½ mm.

Quantitative variation in the genital spot, though more difficult to demonstrate than in the intromittent organ, can be appreciated by comparing the male offspring from the same parents.

It is clear that all the points taken up under the above seven headings apply to the genital spot with quite as much force as to the intromittent organ—the size of the genital spot, like the length of intromittent organ, showing a type of inheritance that is nearly in full accord with Castle's observations on size-characters. In earlier papers these facts were clearly stated in the case of the genital spot (Foot and Strobell, '13 & '14 *a*), but it is interesting to note that Morgan ('14) interprets such evidence quite differently from Castle, for he says, "the authors' evidence shows that it (the genital spot) is inherited as are Mendelian characters" (page 481).

We do not feel justified, in view of the narrow limits of our experiments in genetics, in attempting to draw conclusions as to the possible bearing of

our results on Mendelism, or on the many ingenious hypotheses designed to adapt Mendel's law to some later experimental results. As, however, we are in entire sympathy with Castle's interpretation of size-characters, and believe his thorough knowledge of the subject entitles him to speak with authority, we would quote some of his recent conclusions that appear to us as sustained by the facts of our experimental work on both the intromittent organ and the genital spot of *Euschistus*.

Castle says:—"It is evident that size is not a simple unit character, for there is no dominance and no evidence of segregation other than the increased variability of the second hybrid generation.

"Dominance is clearly absent and the only fact suggesting segregation is the increased variability of the second as compared with the first hybrid generation. This fact, however, may be accounted for on other grounds than the existence of multiple units of varying power.

"If size-differences are due to quantitative variations in special materials within the cell, it is not necessary to suppose that these materials are localized in chunks of uniform and unvarying size, or that they occur in any particular number of chunks, yet the genotype hypothesis involves one or both of these assumptions. Both are unnecessary." (Castle, '12 *a*.)

"The results of all observers, as regards the inheritance of ordinary differences in size, are closely in accord. When two races differing in size are crossed the immediate offspring are intermediate in size. The next generation of offspring is likewise intermediate, but more variable as a rule, and it has been found possible in some cases to select from them forms as extreme in size as the original parents. To interpret such cases as Mendelian, requires the assumption that no single unit or factor is concerned in the size-difference, but many wholly independent units. For a single Mendelizing unit would produce a wholly different result. But suppose we allow the assumption that many independent Mendelizing units or factors are concerned in the inheritance of size. The pure line hypothesis is not benefited by this assumption unless we suppose further that these hypothetical factors do not vary. But this is an assumption wholly without warrant." (Castle, '14 *b*.)

"The *increased variability* of the F_2 generation is the only evidence of Mendelism in size crosses."

"On any hypothesis size-differences must depend on many mutually independent factors or causes . . . It would be rash to assume that all the factors concerned are Mendelizing factors, in the total absence of the two usual accompaniments and criteria of Mendelism, dominance and segregation in recognisable Mendelian ratios." (Page 2.)

He says the facts observed for body-size in rabbits and other quantitative characters in animals and plants are, F_1 intermediate and F_2 also intermediate, but more variable than F_1, and he adds, "If we call this Mendelism, we shall need to explain that it is not the Mendelism of Mendel himself, but original.

Mendelism, *plus* (1) the assumption of gametic purity, *plus* (2) the assumption of factorial constancy, *plus* (3) the assumption of factorial multiplicity" (Castle, '14 *a*).

Results from backcross. F_1 hybrid female (from *E. variolarius* ♀ × *E. servus* ♂) by pure *E. variolarius* male. 18 males, photos 62–66.

This backcross was undertaken to obtain evidence as to whether the so-called male- and female-producing spermatozoa differ in their function in the transmission of the exclusively male character—the genital spot (Foot and Strobell, '13 & '14). We shall briefly re-state this evidence here in order to show that the original results are duplicated by the facts demonstrated in this paper as to the method of transmission of a second exclusively male character—the intromittent organ.

First, the so-called male-producing spermatozoon can transmit the genital spot. This was proved by the fact that the genital spot in the 18 males from this backcross is inherited *much more* strongly from the pure *variolarius* male than from the F_1 hybrid males, and therefore this *variolarius* character was transmitted directly from the male to its male offspring, and must, according to the hypothesis, have been transmitted by the male-producing spermatozoa *. This evidence is repeated in the case of the intromittent organ, for the mean length of the intromittent organ of these 18 males is 113·47 mm., while the mean length of the organ of the F_2 generation is 124·42 mm.—the measure therefore of the influence of the pure *variolarius* male in reducing the length of the intromittent organ may be expressed as 10·95 mm.

Second, this backcross demonstrated in the case of the genital spot that the *servus* character—the absence of spot—was transmitted by the so-called female-producing spermatozoon ; and this evidence of the transmission of an exclusively male character by the female-producing spermatozoon is repeated in the case of the intromittent organ, for the length of the intromittent organ in these 18 males has been increased by the inheritance from *servus*. This is demonstrated by the fact that the mean length of the intromittent organ of the 18 males from this backcross is 113·47 mm., while that of the organ of the 62 pure *variolarius* males is 96·70 mm. The two *servus* characters—absence of spot, and increased length of intromittent organ—must have been transmitted (according to the hypothesis) by the so-called female-producing spermatozoon of *servus* to the pure *variolarius* ♀ of the first cross, through which it was transmitted to her daughter, the F_1 ♀ of this backcross.

The demonstration that the so-called sex-determining spermatozoa do not differ functionally in the transmission of such an exclusively male character

* In making these deductions it is of course necessary to accept, for the sake of the argument, the assumption of male- and female-producing spermatozoa, an assumption which we believe is still far from proved.

as the genital spot would seem to justify a good deal of scepticism of the sex-determination theory which is based on the assumption of male- and female-producing spermatozoa. This scepticism is greatly strengthened by the further evidence that these so-called male- and female-producing spermatozoa do not differ functionally in the transmission of such an exclusively male sexual character as the intromittent organ itself. Further, it seems only logical to believe, if exclusively *male* sexual characters are transmitted by both male- and female-producing spermatozoa, the same must be true also for the exclusively *female* sexual characters, for it is difficult to believe that the two sexes can have such fundamentally different modes of transmission.

If we measure the amount of the *variolarius* inheritance in this backcross, we find an astonishing agreement between the theoretical expectation and the actual result. The relative amount of *variolarius* to *servus* in the offspring of this backcross is 3 to 1, and we should expect, therefore, the mean length of the intromittent organ of *servus* to be reduced by 75 per cent. of the difference between the mean lengths in *variolarius* and *servus*. This difference is 69·71 mm., 75 per cent. of this being 52·28 mm. Deducting this from the mean length of the organ of *servus* (166·41 mm.) would leave 114·13 mm. as the mean length of the organ of the offspring from this backcross. The mean length is in fact 113·47 mm., this being only 0·66 mm. less than the calculated expectation.

These results lose much of their significance in view of the fact that only eighteen males were secured from this backcross, but the results are almost exactly repeated by a backcross with *E. ictericus,* in which 70 instead of 18 males were raised *.

The above method of computing the mean length of organ to be expected in the offspring from the two species, by a simple measure of the relative part each species has contributed in the crossings, is of interest only because the calculated results seem to fit the facts, but it certainly can have no bearing on cases that show the Mendelian type of inheritance, nor where simple unit characters are involved. Neither does it apply to the F_2 generation, for in each of the seven families the mean length is below an exact intermediate.

Table 11 demonstrates that the intromittent organs from the offspring of this backcross fail to show a typical Mendelian ratio, and as this is true also in the case of the genital spot, it is a further proof of the complete agreement in the results obtained from these two exclusively male characters.

* The mean length of the intromittent organ of the offspring from the *variolarius-ictericus* cross is also only a fraction of a millimetre less than the theoretical expectation, but in this cross the slightly stronger inheritance is from the original *male* parent, while in the *variolarius-servus* cross it is from the original *female* parent. In *both* crosses, however, the stronger inheritance is slightly on the side of the *shorter* type of intromittent organ. Our results from the *variolarius-ictericus* cross will be published shortly.

Linkage.

To the cytologist, linkage of characters in inheritance is of special interest because it is claimed that it affords the most trustworthy evidence that the factors determining linked characters are located in the same chromosome, and further it is claimed that this chromosome can be identified. Wilson has recently expressed this view clearly in his Croonian Lecture ('14). After giving a brief summary of the work of Morgan and his pupils on linked characters in *Drosophila,* he adds :—

"This at once suggests that the units of each group (or corresponding things on which they depend) are borne by a particular chromosome which constitutes their common vehicle of transmission, and that to this fact is due their cohesion or linkage in heredity. Conversely, the several groups are independent of one another, because of the independence of the chromosomes which bear them." (Page 344.)

If, as Wilson says, independence in the transmission of characters is due to independence of the chromosomes which bear them, the evidence obtained from our cross-breeding experiments would indicate that the factors determining the transmission of the intromittent organ are not only not carried by a single pair of chromosomes ; but on the above hypothesis it would seem difficult to confine them to the 14 chromosomes, for among the 190 F_2 hybrids there are 69 different lengths of the intromittent organ, and if size-variations are due to multiple unit factors which are transmitted as independent units, these 69 variations would seem to demand an explanation from those who believe that "unit factors" are located in the chromosomes. Further, none of these 69 variations in the F_2 hybrids is consistently linked with any of the variations of the genital spot. We might reduce the number of independent variations of the intromittent organ and the genital spot by consigning most of them to the convenient class called "non-inheritable fluctuations", but this rather arbitrary process must be carried far, if the remaining "unit factors" are to be consigned to a single pair of chromosomes.

The "cross-over hypothesis", which was offered to explain unexpected results in the transmission of characters assumed to be carried by special chromosomes, might be used to excuse non-linkage in these extreme cases ; but we cannot believe that it would be adequate to convince the unprejudiced investigator that the factors determining quantitative variations in the intromittent organ and genital spot are carried and distributed by the chromosomes. Even if we arbitrarily consign the determining factors to special positions in the chromosomes and dictate their subsequent method of division, it does not seem possible to adjust the facts with the view that linkage and non-linkage may have their explanation in chromosome-distribution of the factors.

In our preliminary report of this work (Foot and Strobell, '14 *c*) we discussed the non-linkage of the genital spot and intromittent organ as follows :—

"If factors which stand for a given character are carried by a definite chromosome or pair of chromosomes, and the inheritance of the character is due to a special distribution of the factors at mitosis, it would seem logical to expect that the factors of two characters showing a very special mode of distribution (*i. e.*, exclusively male characters) would be contained in the same chromosome, and that this would be indicated by their being linked in the hybrids. We would expect the absence or presence of the genital spot, distinctive of one species, to be associated in inheritance with the type of intromittent organ characteristic of the same species. Even if the extent to which a character appears is dependent upon hypothetical factors outside the chromosomes, we would expect these hypothetical factors to act equally on two characters which are so closely associated as to be contained in the same chromosome. We should expect the two characters never to be so entirely dissociated that we find, in the same individual, the absence of spot characteristic of one species, associated with the type of intromittent organ distinctive of the other species. Instances of such complete dissociation do, however, occur..... There are instances of association in the inheritance of the two characters, the intromittent organ and genital spot, typical of one of the species occurring in the same F_2 individual; but exact classification of the full results shows that the two characters are transmitted quite independently of each other. The intermediates, having a large range of variation, make it possible for many of them to appear to show the two characters in the association that would be in harmony with the chromosome-hypothesis, but an exact comparison shows two plus and two minus intermediates are quite as frequently associated as are a plus and a minus intermediate."

These facts are demonstrated in the foregoing tables (3–9), in which the type of inheritance of the genital spot and the length of intromittent organ in each particular insect of the F_2 generation are placed side by side. If we examine this evidence in detail, we find that 19 of these 190 F_2 males have a genital spot quite as strong as that of the pure *E. variolarius* male, while only 3 of these 19 males have the *E. variolarius* length of intromittent organ (*i. e.*, between $85\frac{1}{2}$ mm. and 106 mm.).

This evidence of non-linkage is even more clearly shown in those insects which have inherited the *servus* character (absence of the genital spot). There are 74 of these insects, and *only 3* have a length of intromittent organ which can be classed with *servus*, while on the other hand 4 have a length of intromittent organ characteristic of *variolarius*. The remaining 67, which have the absence of genital spot characteristic of *servus*, have a mean length of intromittent organ which shows a stronger influence from *variolarius*.

Tables 3 to 10 further demonstrate that while the influence of *variolarius*

is stronger than *servus* as regards the length of the intromittent organ, these relations are reversed in the case of the genital spot, and this is further demonstrated by those that are classed as intermediates, for of these more are minus than plus intermediates. It is therefore clear beyond question that these two exclusively male characters, the genital spot and the intromittent organ, are not linked in inheritance. These results are certainly out of harmony not only with the chromosome-hypothesis of sex-determination, but with the recent hypotheses of chromosome-distribution of unit factors.

The evidence from the F_1 generation is of less value, as we have only 11 specimens showing the inheritance of the genital spot, and we were not able to measure the length of intromittent organ of all the eleven, as one was destroyed in dissection.

The results from the F_1 generation are as follows:—2 of the eleven F_1 hybrids are like *servus* in having no genital spot, and the remaining 9 are variable intermediates. The two that have the *servus* inheritance (without a genital spot) have the following lengths of intromittent organ—126 mm. and 124 mm.; these lengths showing a stronger inheritance from *variolarius* as to the intromittent organ, while both insects show an exclusively *servus* inheritance in the absence of the genital spot.

The F_1 hybrid that has the longest intromittent organ—134 mm. (photo 11) —has the strongest genital spot of all the eleven F_1 hybrids, this again demonstrating a significant absence of linkage in these two exclusively male characters.

The mean length of the intromittent organs of the 10 F_1 hybrids is 124·9 mm., this demonstrating a stronger inheritance from *variolarius* than from *servus*. The difference between the mean length of *variolarius* (96·70 mm.) and of *servus* (166·41 mm.) is 69·71 mm., and therefore an exact intermediate between these two means would be 131·55 mm.—the measure therefore of the stronger *variolarius* inheritance in these F_1 hybrids may be expressed by 7·46 mm.

It is an interesting fact that the intromittent organ not only of this F_1 generation, but also of the F_2 generation, shows a stronger inheritance from *variolarius* than from *servus*, the measure of the greater *variolarius* influence being almost the same for the two generations, *i. e.*, 7·46 mm. in the case of the F_1 hybrids, and 7·13 mm. in the case of the F_2 hybrids.

While the intromittent organ of these 190 males shows a stronger inheritance from the *female* original parent (*variolarius*), the reverse is true of the genital spot, for only 19 of these 190 males have a spot as strong as *variolarius*, while 74 are like the *male* original part (*servus*) in having no spot.

It is not possible to make an accurate estimate of the influence of the two species on the type of genital spot classed as intermediate, but there are certainly more minus than plus intermediates, this further demonstrating that the genital spot shows a stronger inheritance from *servus* than from *variolarius*.

The results from the backcross demonstrate again that the genital spot and the intromittent organ are not linked in inheritance (Table 11). Twelve of these eighteen specimens have the *E. variolarius* spot on the genital segment, while only three have a length of intromittent organ characteristic of *variolarius*. Six have a spot on the genital segment which is more or less reduced by the inheritance from *E. servus*, which has no genital spot. These six are therefore intermediate as to the genital spot, while there are fifteen intermediate in the length of the intromittent organ.

Chromosomes.

Our experiments with these hemiptera were undertaken with the aim of testing some recent chromosome-theories of sex-determination by the trustworthy method of experimental cross-breeding. For this purpose we selected an exclusively male character—the distinct dark spot which is present on the genital segment of *Euschistus variolarius* and absent in *Euchistus servus*, for this character appeared to us well adapted to test the function of the so-called sex-chromosomes in the transmission of an exclusively male character.

The results of these cross-breeding experiments and their bearing on the chromosome-theories of sex-determination have been discussed in earlier papers, Foot and Strobell, '13 and '14 *a* & *b*. In the present paper we will summarize the evidence in order to demonstrate that the results gained by the study of the transmission of the genital spot are in fact duplicated in the case of the intromittent organ, and that therefore not only is the evidence gained through the study of the first greatly strengthened, but the conclusions bearing on chromosome-theories are fully sustained on every point.

In the preliminary report of our results from the study of this second exclusively male character we gave what appear to us very cogent reasons for claiming that this character should be classed as a primary sexual character. Both Morgan ('13) and Doncaster ('14*a* & '14*b*), in the case of the genital spot summarily dispose of our results and our claim that they have a valid bearing on the chromosome sex-determination hypothesis, by simply classing the genital spot with secondary sexual characters. Although there might be some ground for classing the genital spot with these characters, they are quite unlike in a most important feature, for a marked characteristic of the secondary sexual characters of authors is the fact that they can, almost without exception, be bred into the opposite sex. We do not believe that even these critics can thus dismiss the evidence obtained from a study of the transmission of the intromittent organ, although this evidence confirms in every detail the results demonstrated in the transmission of

the genital spot. For convenience we repeat the argument from our preliminary report.

Both Morgan and Doncaster class the genital spot of *variolarius* with the secondary sexual characters of authors, and they therefore interpret our results as not having the bearing on the theories of sex-determination which we claim for them. Now our claim has been that the genital spot of *variolarius* is an integral part of the male genital segment—the structure of the female genital segment being such that the spot could not be present in this segment without changing the form of the segment itself—and we have claimed that therefore a study of the transmission of the genital spot should give a trustworthy indication of the method of transmission of the entire genital segment.

This claim, that the method of transmission of the genital spot should be an index of the method of transmission of the genital organs of the male, has been completely justified by further work on these hybrids. . . The genetic results from our study of the genital spot of *variolarius* may be open to the criticism that as the spot is "not directly connected with the act of reproduction" it should be classed with the secondary sexual characters; but the intromittent organ is certainly free from such criticism and can be justly classed as a primary sexual character. In view of the fact that our results from the study of the transmission of the *variolarius* spot have been set aside on the ground that the spot is a secondary sexual character, and therefore has no bearing on the problem of the determination of sex, it is necessary first to establish the claim that the intromittent organ can be classed with the primary and not the secondary sexual characters. This apparently ought not to be difficult, but a difficulty does arise owing to the fact that recent authors who have discussed secondary sexual characters have avoided defining them, and have neglected to state wherein they are to be distinguished from the primary sexual characters.

According to Darwin ('59) Hunter defines secondary sexual characters as follows:—

"The term, secondary sexual characters, used by Hunter, applies to characters which are attached to one sex; but are not directly connected with the act of reproduction."

Darwin ('86) adopts Hunter's classification of primary and secondary sexual characters, but shows that even such an apparently clear-cut definition encounters difficulties. He says* :—"With animals which have their sexes separated, the males necessarily differ from the females in their organs of reproduction; *and these afford the primary sexual characters.* But the sexes often differ in what Hunter has called secondary sexual characters, which are *not directly connected with the act of reproduction* ; for instance, in

* The italics are ours.

the male possessing certain organs of sense or locomotion, of which the female is quite destitute, or in having them more highly developed, in order that he may readily find or reach her; or again, in the male having special organs of prehension so as to hold her securely. These latter organs of infinitely diversified kinds graduate into, and in some cases can hardly be distinguished from, those which are commonly ranked as primary, such as the complex appendages at the apex of the abdomen in male insects. Unless indeed we confine the term 'primary' to the reproductive glands, it is scarcely possible to decide, as far as the organs of prehension are concerned, which ought to be called primary and which secondary" (p. 253).

Morgan ('13) also appears to accept Hunter's classification, for in his rather full list of secondary sexual characters he includes none that are "directly connected with the act of reproduction." He opens his discussion of secondary sexual characters as follows :—

"The Secondary Sexual Characters.

"In the most highly evolved stages in the evolution of sex a new kind of character makes its appearance. This is the *secondary sexual character*. In most cases such characters are more elaborate in the male, but occasionally in the female. They are the most astonishing thing that nature has done : brilliant colours, plumes, combs, wattles, and spurs, scent-glands (pleasant and unpleasant) ; red spots, yellow spots, green spots, topknots and tails, horns, lanterns for the dark, songs, howlings, dances and tourneys—a medley of odds and ends" (p. 26).

If we are to discard Hunter's classification, because it is found difficult to determine to which class some of the characters rightly belong, we should have to be dissatisfied with many classifications that are thoroughly well established.

If we limit the term "primary sexual characters" to the reproductive glands, it offers an escape from the difficulties in classifying the prehensile organs, as Darwin has pointed out; but it would seem that greater difficulties are met by refusing to place the intromittent organ in the same group with the reproductive glands, and placing it in the group with characters so far removed from "direct connection with the act of reproduction", as, for example, Morgan's list of secondary sexual characters. The intromittent organ is not only "directly connected with the act of reproduction", but it is as much a part of the sex of the individual as the reproductive glands themselves. Any one of the characters in Morgan's entire list of male secondary sexual characters could appear in the female without changing her sex; but the intromittent organ is as clearly indicative of the sex as are the reproductive glands themselves.

If a definite chromosome carries the factors for determining sex, and it therefore carries the factors for the reproductive glands, it would seem logical to suppose that the chromosome carrying the factors necessary for

the development of the male reproductive glands would also carry the factors necessary for the development of the intromittent organ which, when present, is functionally a necessary adjunct of the glands, and as indicative of the sex as the reproductive glands themselves. If we cannot accept the mode of transmission of the intromittent organ as an index of the mode of transmission of the reproductive glands, it would seem necessary to discard all structural features or other characters which are distinctive of the gonads of a given species, such as their distinction in size, form, colour, etc., and assume that these characters, associated with the gland, have a different mode of transmission from the gland itself.

This would prevent any experimental test being applied to the chromosome-theories of sex-determination and leave free scope for the wildest cytological speculations. If we should place the intromittent organ in the group of secondary sexual characters, because it has certain features in common with these characters, we ought logically to place the reproductive glands themselves in the same group. For example, both these organs, in common with most of the secondary sexual characters, can be transmitted to the opposite sex—hermaphrodites appearing in forms that are normally sexually distinct A case in point is Goodrich's ('12) interesting and important discovery of a male amphioxus in which 49 of the gonads were testes containing ripe spermatozoa and one was an ovary containing ripe ova. It may be urged that the intromittent organ is a secondary sexual character on the evidence that in the development of the embryo it appears much later than do the gonads—this indicating that the gonads are more fundamental and stable morphological entities. But there are facts opposed to this interpretation—Smith ('10) found that when the spider crab is infected by the parasite sacculina, the testes can become so greatly metamorphosed that some of the cells may develop into ova and *the same testis* contain *both* ripe ova and spermatozoa.

It would seem that the division between primary and secondary sexual characters, in common with almost all attempts at classification, has the objection that the line of demarcation is not, at all points, perfectly clear; but we believe, in spite of this, that we are justified in classing the intromittent organ as a primary sexual character, and that the results from the study of the transmission of this organ may justly be claimed as an index of the method of transmission of the reproductive glands themselves.

In the case of the genital spot the bearing of our results on recent chromosome-theories has been fully discussed in our earlier papers. We believe we clearly demonstrated that the facts are entirely out of harmony with all those hypotheses which claim to offer an explanation of the transmission of characters by the assumption that factors essential to their transmission are carried and distributed by definite chromosomes.

We have briefly summarized these results in a recent paper (Foot and Strobell, '14 *a*), and this summary will serve equally well for the second exclusively male character—the intromittent organ. This can be demonstrated by quoting the summary and changing it only enough to include the intromittent organ with the genital spot, as follows :—

First. Both the genital spot and the type of intromittent organ characteristic of each species can be inherited without the aid of the Y chromosome. This is proved by the fact that both are transmitted through the female, and the female does not possess the Y chromosome, as this chromosome is an exclusively male character.

Second. Both the genital spot and the type of intromittent organ can be inherited without the aid of the X chromosome. This is proved by the fact (demonstrated by the backcross) that they are transmitted through the male and *ex hypothesi* the male-producing spermatozoon does not have an X chromosome*.

We add, "In making these deductions it is, of course, necessary to accept, for the sake of the argument, the assumption of male- and female-producing spermatozoa, an assumption which, we believe, is far from proved." (See backcross p. 473.)

Third. The results show that if we assume that the factors necessary for the production of the genital spot and the intromittent organ are located in any of the ordinary chromosomes, they must be in at least both members of a pair of ordinary chromosomes, for the spot is directly transmitted through both the male and the female.

Fourth. The results show that, if we assume that the factors necessary for the production of the genital spot and the intromittent organ are carried by both members of a pair of chromosemes, we must assume that the female carries an inhibitor for the spot as well as for the intromittent organ, for neither is present in any of the females, though both are transmitted by the female, and therefore the factors for both are present, though not expressed.

Fifth. The results show that, although it is necessary to assume an inhibitor only in the *females* of the pure species, in the hybrids it becomes necessary to assume an inhibitor in the *males* also.

In his recent criticism of our work, Morgan ('14) overlooks the fact that the F_1 hybrid *males* have the spot more or less suppressed. In these males it is partly or wholly absent, and yet (like the females) they can directly

* Morgan ('14) seems to think that this point could have been made solely from the evidence of the F_2 ratio. He says: "It is unnecessary to repeat their argument; for if the factors were carried by the X chromosome only half the grandsons should show it, while, in fact, many more than half of them show it." We do not feel that this evidence would be conclusive, for it could be attacked by the assumption of an unequal death-rate—a convenient assumption which has been used more than once to excuse contradictory evidence.

transmit the spot to their male offspring. It seems only logical to believe that the causes, whatever they are, which inhibit the spot in the females are also responsible for its total or partial suppression in the F_1 hybrid males, but the causes suggested by our critics to account for its suppression in the females obviously cannot apply to the male hybrids. Morgan ('14), after admitting that the spot factors cannot be carried by the X or the Y chromosome, adds :—"We are concerned then only with a third possibility, viz. that there is something in the female condition itself that is inimical to the development of the spot." This something, he later explains, is the two X chromosomes. He says :—"The chemical interaction between two X's and the rest of the cell is of such kind that it produces a female, and the female complex, as such, is inimical to the development of a spot."

To the defenders of the chromosome-hypotheses, this may seem a plausible explanation of the suppression of the spot in the females which have these two X chromosomes, but it leaves unexplained the fact that the spot in the F_1 males is either wholly or partly suppressed, and these males have only one X chromosome, while two X chromosomes are held responsible for the suppression of the spot in the females.

The facts forced us to assume some sort of hypothetical inhibiting factors for the spot, not only for the females but for the F_1 male hybrids as well, and this is equally necessary for the case of the intromittent organ, since it is not only wholly inhibited in the females, but the length of organ strictly characteristic of either of the pure species is more or less inhibited in the F_1 hybrids. Further, the intromittent organ is like the spot in reappearing in the next generation in the length typical of the two parent species, proving this to have been latent in both the females and the F_1 males—its full expression being inhibited by unknown factors.

Sixth. The facts show, in the case of the genital spot, and we may now add in the case of the intromittent organ as well, that if we attempt to place this inhibitor in definite chromosomes, we meet with as serious difficulties as those involved in assuming that the factors essential for the production of the genital spot are carried by special chromosomes. In our preliminary report of these experiments ('13), we discussed in full the evident results of placing this inhibitor in various chromosomes—in the X chromosomes, in one of the ordinary chromosomes, or in a pair of chromosomes ; and we found that none of these assumptions would accord with the facts. "The facts force us to regard these inhibitors as hypothetical forces which cannot logically be confined to the chromosomes, and are located we know not where—these hypothetical inhibitors practically doing work that has been assigned to definite chromosomes."

If the chromosome-hypotheses have a foundation in fact, it would seem only logical to expect that in these insects the Y chromosome should carry the factors for exclusively male characters, for it is the only one of the

14 chromosomes that is never present in the female, and is present in *all* the so-called male-producing spermatozoa, while each of the 13 autosomes (according to their accepted mode of division) can be present in half the male-producing and half the female-producing spermatozoa, and therefore in both half the males and half the females.

Even the defenders of the chromosome sex-determination hypothesis reject this Y chromosome as the carrier of factors essential for the determination of sex, for the very cogent reason that in so many forms no Y chromosome is present. Morgan ('11) concludes that "the factors for producing the male must be located in some other chromosome."

As the Y chromosome is thus rejected as a sex-determiner, it would seem that those who hold that factors essential for the development of definite characters are carried by definite chromosomes are forced to assign to the Y chromosome (in forms in which it is present) the function of carrying factors essential for the development of characters exclusively male, since, as stated above, it is the *only* chromosme that is *always* present in the male and absent in the female. We have shown, however, that such exclusively male characters as the genital spot and the intromittent organ can be inherited without the Y chromosome, and this certainly challenges such an interpretation, and leads us to respectfully ask the advocates of the chromosome-hypotheses what characters they would assign to it.

An ingenious apology for the obvious shortcomings of the sex-chromosome hypothesis has been recently made by C. B. Bridges, '13 (one of Morgan's pupils). It is offered as an explanation of occasional slips in linkage. Bridges found in *Drosophila ampelophila* that two sex-linked characters (red eye and white eye) failed to show linkage in 5 per cent. of the cases (Wilson, '14, states that these exceptions are "about 10 per cent.").

To the class of cytologists to which Bridges belongs, "sex-linked characters" are in reality *X-linked*, and therefore, for example, it is theoretically impossible for a male to transmit directly to his male offspring a character that is assumed to be carried by the X chromosome—the chromosome that is absent from the male-producing spermatozoon. In order then to explain away these embarrassing slips in linkage, Bridges has submitted the following ingenious explanation, which is based on the admission that the X chromsomes do not move during maturation with that military precision heretofore demanded by the theories. He now suggests each may show an equal amount of erratic movement—the one destined for the polar body may remain in the egg, and the one destined to remain in the egg may go with its mate to the polar body; and thus three kinds of ripe eggs are possible—the first with the usual one X, the second with no X at all, and the third with two X's. This erratic behaviour of the X chromosomes can be made to account for many disappointments in expected results,

and incidentally it relieves the so-called male- and female-producing spermatozoa *as such* from the responsibility of deciding the sex, and places it squarely with the egg, for from a so-called male-producing spermatozoon a female can develop if this spermatozoon fertilizes an egg in which both X chromosomes have remained, and again from a so-called female-producing spermatozoon a male can develop if this spermatozoon fertilizes an egg which has no X chromosome.*

It is naturally incumbent upon the cytologist who makes assumptions so necessary for the defence of a theory to find some cytological proof of them, and Wilson ('14) has made the interesting announcement that "very recently Bridges has tested his assumption cytologically". And he adds, "The cytological examination has demonstrated that certain females of this race actually possess three of these chromosomes."

Wilson seems to regard this evidence as quite conclusive proof of Bridges' assumptions and deductions. Those of us, however, who have no such sublime faith in the causal nature of the chromosomes are inclined to suspect that if Bridges had searched with equal ardour for an extra X chromosome in the male cells, he might have found these cells also equipped with an extra X chromosome, as in fact we found to be the case in the spermatogonia of *Anasa tristis* (Foot and Strobell, '07). In spite of our demonstrating this second X chromosome by photomicrographs, the reality of its presence has been questioned by advocates of the chromosome-theories, for it is obviously an embarrassing factor to the sex-determination hypothesis.

Further study of the chromosomes of the Hemiptera led us to make the following statement which seems to us to have some bearing on Bridges' recent discovery:—"A careful examination of our preparations makes it possible to select chromosome-groups which exactly fit a given theory, but many groups can also be found that are a serious menace to these theories, while, on the other hand, they present no difficulties to the conception of those who regard the number, size, and form of the chromosomes as inherited characters—the expression of cell-activities rather than the cause."

In our preliminary report (Foot and Strobell, '14 *c*, pp. 228–31) we showed by an analysis of the chromosomes, based on the hypotheses as to their method of division, that the testis itself can have no closer relation to the so-called sex-determining chromosomes than we have shown to be the case

* Bridges' assumptions, when applied to those forms which have a Y chromosome, would seem to relieve this chromosome of any sex-limited function, although in these species it is just as distinctive of the male cells as are the two X chromosomes of the female cells. According to Bridges' hypothesis, some males may be without the Y chromosome, while some females have it. The admission that such marked structural changes in the male and female chromosome groups can occur in individuals is in harmony with the belief that the chromosomes, like other structures in the cell, are the expression rather than the cause of cell activities.

for the other two exclusively male characters—the genital spot and the intromittent organ. These three exclusively male characters—the genital spot, the intromittent organ, and the testis—can therefore, according to the hypothesis, be transmitted by the female-producing spermatozoon as well as by the male-producing spermatozoon.

The defenders of the chromosome-hypothesis of sex-determination would have us ignore these facts. Morgan ('14) says :—"To assume that all the factors for characters that are shown by the male or by the female must be carried by a sex-chromosome *of some kind*, if carried at all by chromosomes, is a travesty of the point of view of those who hold to the chromosome-hypothesis as a reasonable working hypothesis to account for Mendelian inheritance." This sounds like an effort to evade the force of the real facts. It should be added that two of these "*characters*" (the intromittent organ and the testis) are so exclusively male that without them the insect would not be a male, and to present these facts and the conclusions which they logically involve can scarcely be called "*a travesty*" of the hypothesis that asserts that factors determining sex are carried and distributed by "*sex-chromosomes*." Rather it is a serious and perfectly logical challenge of some recent extreme views as to the function of the chromosomes in heredity.

Oxford, March 1915.

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EXPLANATION OF THE PLATES.

All the preparations were photographed at exactly the same magnification (20 diameters), and the photograph of each intromittent organ was carefully measured with a small pair of architect's dividers, fitted with number nine needle-points, and set at 2 mm. The dividers were frequently tested by measuring a line of a definite length. The measurements were made on matte prints, so that each division of 20 mm. could be identified by a pencil-mark and numbered. Measurement of the longer and more closely coiled organs was facilitated by dotting the first coil with red ink, the second coil with blue ink, and leaving the third coil black. In this way the longest coil could then be measured with as much accuracy as the shortest. The measurements were made from the distal end of the intromittent organ to the point where the thick part of the coil enters the gland. At this point the coil is easily dissected off (*e. g.*, photos 12 & 13), but even in those cases where part of the canal within the gland has been preserved (*e. g.*, photo 1) the point from which the measurement was taken is easily determined, for the part within the gland is transparent and quickly tapers to a very fine canal.

The intromittent organs of photos 1 to 66 are from the same insects which were photographed in an earlier paper and published in this same volume of the Journ. Linn. Soc., Zool. (see Plates **28** to **34**).

In order to demonstrate whether these two exclusively male characters—the genital spot and the intromittent organ—are linked in inheritance, we have placed the intromittent organs of photos 1 to 66 in exactly the same order in which the photographs of the bugs themselves were placed on the plates of the above-mentioned paper—each photograph in the two sets of illustrations *exactly corresponding*, and thus admitting an accurate comparison of the genital spot and the intromittent organ of each individual bug of the entire series.

The photographs are reproduced by the half-tone method. Frequently it does not accurately reproduce the distal end of the intromittent organs, which always terminate in a clean-cut oblique angle: this is sometimes obscured by the dotted effect of the half-tone method, giving the appearance of a broken, jagged end. In some cases the reproducers have attempted to correct this by retouching; but this has not always been successful.

Plate **41**.

(*Cf.* Plate **28** of this volume.)

Photo 1. Intromittent organs from the two bugs of photo 1, plate 28. On the left *E. variolarius*, and on the right *E. servus*. Length of intromittent organ of *E. variolarius* 95 mm., of *E. servus* 167 mm.

Photo 2. Intromittent organs from the seven *E. variolarius* of photo 2, plate 28. These insects were raised in our laboratory during the summer of 1912. The parent bugs were raised in our laboratory during the summer of 1911, and were kept in captivity during the winter of 1911–12. Lengths of the intromittent organs of the seven bugs are as follows:—1st (upper), 96 mm. 2nd, 101 mm. 3rd, 96 mm. 4th, 93 mm. 5th, 90 mm. 6th, 96 mm. 7th, 92 mm.

Photo 3. Intromittent organs from the five *E. servus* of photo 3, plate 28. The bugs were collected in North Carolina in the fall of 1912. Lengths of the intromittent organs:—1st (upper), 164½ mm. 2nd, 164½ mm. 3rd, 175½ mm. 4th, 166 mm. 5th, 170 mm.

Photo 4. Intromittent organ of the wild *E. servus* of photo 4, plate 28. This male fertilized the *E. variolarius* female used for our cross-breeding experiments. Length of intromittent organ, 166 mm.

PHOTO 5. Intromittent organs of the five *E. servus* that were caged during the winter of 1911–12 with three *E. variolarius* females, one of which was used for our cross-breeding experiments. (The last three of these five males are shown in photo 5, plate 28.) Lengths of the intromittent organs:—1st (upper), 161 mm. 2nd, 162 mm. 3rd, 166 mm. 4th, 146 mm. 5th, 169 mm.

PHOTO 6. Intromittent organs from two *E. variolarius*. These males were raised from the same deposition of eggs from which we raised the females for our cross-breeding experiments. Only one of these males (the 2nd) is shown in photo 5, plate 28. Lengths of the intromittent organs:—1st (upper), 104 mm. 2nd, 94 mm.

PHOTO 7. Intromittent organs from the two F_1 hybrids of photo 7, plate 28. Lengths of the intromittent organs:—1st (upper), 126 mm. 2nd, 124 mm.

PHOTO 8. Intromittent organs from the two F_1 hybrids of photo 8, plate 28. Lengths of the intromittent organs:—1st (upper), 126 mm. 2nd, 124 mm.

PHOTO 9. Intromittent organ from the one F_1 hybrid that was preserved as a pinned specimen. This is the only intromittent organ that cannot be compared with a photograph of the insect from which it was dissected. The intromittent organ of the insect of photo 9, plate 28, was broken in dissection, and we therefore replaced it with this organ from the dried specimen. Length, 126 mm.

PHOTO 10. Intromittent organ of the F_1 hybrid of photo 10, plate 28. Length of intromittent organ, 109 mm. (This includes 3 mm. for the extreme distal end that was broken off in dissection and not preserved.) This hybrid is the male parent of the F_2 hybrids of plate 31.

PHOTO 11. Intromittent organ of the F_1 hybrid of photo 11, plate 28. Length of intromittent organ, 134 mm.

This hybrid is the male parent of the F_2 hybrids of photos 15 and 16, plate 28.

PHOTO 12. Intromittent organ of the F_1 hybrid of photo 12, plate 28. Length of intromittent organ, 132 mm.

This hybrid is the male parent of the F_2 hybrids of photos 42 to 48, plate 32.

PHOTO 13. Intromittent organ of the F_1 hybrid of photo 13, plate 28. Length of intromittent organ, 122 mm.

This male fertilized the two F_1 females of the 6th and 7th pairs of F_1 hybrids, and is therefore the male parent of the F_2 hybrids of photos 49 to 57, plates 32 & 33.

PHOTO 14. Intromittent organ of the F_1 hybrid of photo 14, plate 28. Length of intromittent organ, 126 mm.

This hybrid is the male parent of the F_2 hybrids of photos 26 to 32, plate 30.

PHOTOS 15 & 16. Intromittent organs from the four F_2 males from the fifth pair of F_1 hybrids.

PHOTO 15. Intromittent organs of the three F_2 hybrids of photo 15, plate 28. Length of intromittent organs:—1st (upper), 108 mm. 2nd, 107½ mm. 3rd, 147 mm.

PHOTO 16. Intromittent organ of the F_2 hybrid of photo 16, plate 28. Length of intromittent organ, 135 mm. (See photo 11 for the intromittent organ of the male parent of the four F_2 hybrids of photos 15 and 16.)

Plate 42.

(*Cf.* Plate 29 of this volume.)

The intromittent organs from 43 F_2 males from the first pair of F_1 hybrids. The male parent of these hybrids is shown in photo 9, plate 28, but we did not succeed in preserving its intromittent organ (see photo 9).

Photo 17. Intromittent organs from the five F_2 hybrids of photo 17, plate 29. Lengths of intromittent organs:—1st (upper), 96 mm. 2nd, 146 mm. 3rd, 130 mm. 4th, 136 mm. 5th, 150 mm.

Photo 18. Intromittent organs from the five F_2 hybrids of photo 18, plate 29. Lengths of intromittent organs:—1st (upper), 112½ mm. 2nd, 128 mm. 3rd, 122 mm. 4th, 137 mm. 5th, 148 mm.

Photo 19. Intromittent organs of the four F_2 hybrids of photo 19, plate 29. Lengths of intromittent organs:—1st (upper), 114 mm. 2nd, 129 mm. 3rd, 139½ mm. 4th, 144 mm.

Photo 20. Intromittent organs of the three F_2 hybrids of photo 20, plate 29. Lengths of intromittent organs:—1st (upper), 130 mm. 2nd, 120 mm. 3rd, 98 mm.

Photo 21. Intromittent organs of the six F_2 hybrids of photo 21, plate 29. Lengths of intromittent organs:—1st (upper), 124 mm. 2nd, 152 mm. 3rd, 133 mm. 4th, 122 mm. 5th, 136 mm. 6th, 97 mm.

Photo 22. Intromittent organs of the five F_2 hybrids of photo 22, plate 29. Lengths of intromittent organs:—1st (upper), 136 mm. 2nd, 146 mm. 3rd, 124 mm. 4th, 128½ mm. 5th, 130 mm.

Photo 23. Intromittent organs of the four F_2 hybrids of photo 23, plate 29. Lengths of intromittent organs:—1st (upper), 98 mm. 2nd, 120 mm. 3rd, 104 mm. 4th, 122 mm.

Photo 24. Intromittent organs of the three F_2 hybrids of photo 24, plate 29. Lengths of intromittent organs:—1st (upper), 100 mm. 2nd, 114 mm. 3rd, 132½ mm.

Photo 25. Intromittent organs of the eight F_2 hybrids of photo 25, plate 29. Lengths of intromittent organs:—1st (upper), 114½ mm. 2nd, 123 mm. 3rd, 100 mm. 4th, 108 mm. 5th, 93 mm. 6th, 132 mm. 7th, 85½ mm. 8th, 140 mm.

Plate 43.

(*Cf.* Plate 30 of this volume.)

Intromittent organs from 30 F_2 males, from the second pair of F_1 hybrids. The male parent of these hybrids is shown in photo 14, plate 28, and its intromittent organ in photo 14, Plate 41.

Photo 26. Intromittent organs from the five bugs of photo 26, plate 30. Lengths of intromittent organs:—1st (upper), 115½ mm. 2nd, 100 mm. 3rd, 116 mm. 4th, 118 mm. 5th, 118 mm.

Photo 27. Intromittent organs from the four bugs of photo 27, plate 30. Lengths of intromittent organs:—1st (upper), 99 mm. (this includes 3 mm. for the extreme distal end that was broken off in dissection and not preserved). 2nd, 130 mm. 3rd, 130 mm. 4th, 130 mm.

Photo 28. Intromittent organs from the six bugs of photo 28, plate 30. Lengths of intromittent organs:—1st (upper), 90 mm. 2nd, 142 mm. 3rd, 124 mm. 4th, 131 mm. 5th, 121 mm. 6th, 127½ mm.

Photo 29. Intromittent organs from the five bugs of photo 29, plate 30. Lengths of intromittent organs:—1st (upper), 124 mm. 2nd, 123 mm. 3rd, 125 mm. 4th, 126 mm. 5th, 126 mm.

PHOTO 30. Intromittent organs from the four bugs of photo 30, plate 30. Lengths of intromittent organs:—1st (upper), 130 mm. 2nd, 134½ mm. 3rd, 115½ mm. 4th, 133 mm. (this includes 3 mm. for the extreme distal end that was broken off in dissection and not preserved).

PHOTO 31. Intromittent organs from the three bugs of photo 31, plate 30. Lengths of intromittent organs:—1st (upper), 114 mm. 2nd, 114 mm. 3rd, 99½ mm.

PHOTO 32. Intromittent organs from the three bugs of photo 32, plate 30. Lengths of intromittent organs:—1st (upper), 114½ mm. 2nd, 122 mm. 3rd, 127 mm.

PLATE 44.

(*Cf.* Plate **31** of this volume.)

Intromittent organs from 48 F_2 males from the third pair of F_1 hybrids. The male parent of these hybrids is shown in photo 10, plate 28, and its intromittent organ in photo 10, Plate **41**.

PHOTO 33. Intromittent organs from the six bugs of photo 33, plate 31. Lengths of intromittent organs:—1st (upper), 117½ mm. 2nd, 124 mm. 3rd, 116½ mm. 4th, 144 mm. 5th, 123½ mm. 6th, 130 mm.

PHOTO 34. Intromittent organs from the eight bugs of photo 34, plate 31. Lengths of intromittent organs:—1st (upper), 128 mm. 2nd, 131 mm. 3rd, 140 mm. 4th, 130 mm. 5th, 140 mm. 6th, 121 mm. 7th, 123 mm. 8th, 147 mm.

PHOTO 35. Intromittent organs from the five bugs of photo 35, plate 31. Lengths of intromittent organs:—1st (upper), 104 mm. 2nd, 115 mm. 3rd, 126 mm. 4th, 134 mm. 5th, 134½ mm.

PHOTO 36. Intromittent organs from the seven bugs of photo 36, plate 31. Lengths of intromittent organs:—1st (upper), 114 mm. 2nd, 127½ mm. 3rd, 127½ mm. 4th, 124 mm. 5th, 142 mm. 6th, 120 mm. 7th, 127½ mm.

PHOTO 37. Intromittent organs from the three bugs of photo 37, plate 31. Lengths of intromittent organs:—1st (upper), 122½ mm. 2nd, 122½ mm. 3rd, 126 mm.

PHOTO 38. Intromittent organs from the five bugs of photo 38, plate 31. Lengths of intromittent organs:—1st (upper), 112 mm. 2nd, 120 mm. 3rd, 126 mm. 4th, 139½ mm. 5th, 140 mm.

PHOTO 39. Intromittent organs from the four bugs of photo 39, plate 31. Lengths of intromittent organs:—1st (upper), 137 mm. 2nd, 134½ mm. 3rd, 140 mm. 4th, 124 mm.

PHOTO 40. Intromittent organs from the seven bugs of photo 40, plate 31. Lengths of intromittent organs:—1st (upper), 114½ mm. 2nd, 117 mm. 3rd, 122 mm. 4th, 136½ mm. 5th, 126 mm. 6th, 126½ mm. 7th, 120 mm.

PHOTO 41. Intromittent organs from the three bugs of photo 41, plate 31. Lengths of intromittent organs:—1st (upper), 116½ mm. 2nd, 132 mm. 3rd, 126 mm.

PLATE 45.

(*Cf.* Plate **32** of this volume.)

PHOTOS 42-48. Intromittent organs from the 27 F_2 males from the fourth pair of F_1 hybrids. The male parent of these hybrids is shown in photo 12, plate 28, and its intromittent organ in photo 12, Plate **41**.

PHOTO 42. Intromittent organs from the four bugs of photo 42, plate 32. Lengths of intromittent organs:—1st (upper), 142 mm. 2nd, 130 mm. 3rd, 130½ mm. 4th, 136 mm.

PHOTO 43. Intromittent organs from the seven bugs of photo 43, plate 32. Lengths of intromittent organs :—1st (upper), 118½ mm. 2nd, 132 mm. 3rd, 140 mm. 4th, 133 mm. 5th, 127 mm. 6th, 138 mm. 7th, 141½ mm.

PHOTO 44. Intromittent organs from the two bugs of photo 44, plate 32. Lengths of intromittent organs :—1st (upper), 115 mm. 2nd, 127 mm.

PHOTO 45. Intromittent organs from the three bugs of photo 45, plate 32. Lengths of intromittent organs :—1st (upper), 128 mm. 2nd, 136 mm. 3rd, 137 mm.

PHOTO 46. Intromittent organs from the six bugs of photo 46, plate 32. Lengths of intromittent organs :—1st (upper), 116½ mm. 2nd, 128 mm. 3rd, 122 mm. 4th, 120 mm. 5th, 136 mm. 6th, 127 mm.

PHOTO 47. Intromittent organs from the four bugs of photo 47, plate 32. Lengths of intromittent organs :—1st (upper), 119½ mm. 2nd, 110 mm. 3rd, 142 mm. 4th, 121 mm.

PHOTO 48. Intromittent organ from the male of photo 48, plate 32. Length of intromittent organ, 110 mm.

PHOTOS 49 & 50. Intromittent organs from the six F_2 males from the sixth pair of F_1 hybrids. The male parent of these hybrids is shown in photo 13, plate 28, and its intromittent organ in photo 13, Plate **41**.

PHOTO 49. Intromittent organs from the two bugs of photo 49, plate 32. Lengths of intromittent organs :—1st (upper), 113½ mm. 2nd, 129½ mm.

PHOTO 50. Intromittent organs from the four bugs of photo 50, plate 32. Lengths of intromittent organs :—1st (upper), 128 mm. 2nd, 128 mm. 3rd, 125 mm. 4th, 134 mm.

PLATE **46**.

(*Cf.* Plate **33** of this volume.)

Intromittent organs from 32 F_2 males from the seventh pair of F_1 hybrids. The male parent of these hybrids is shown in photo 13, plate 28, and its intromittent organ in photo 13, Plate **41**.

PHOTO 51. Intromittent organs from the nine bugs of photo 51, plate 33. Lengths of intromittent organs :—1st (upper), 110 mm. 2nd, 120 mm. 3rd, 131 mm. 4th, 119 mm. 5th, 136½ mm. 6th, 121½ mm. 7th, 138 mm. 8th, 115 mm. 9th, 122 mm.

PHOTO 52. Intromittent organs from the six bugs of photo 52, plate 33. Lengths of intromittent organs :—1st (upper), 127 mm. 2nd, 123½ mm. 3rd, 112 mm. 4th, 128 mm. 5th, 120 mm. 6th, 136 mm.

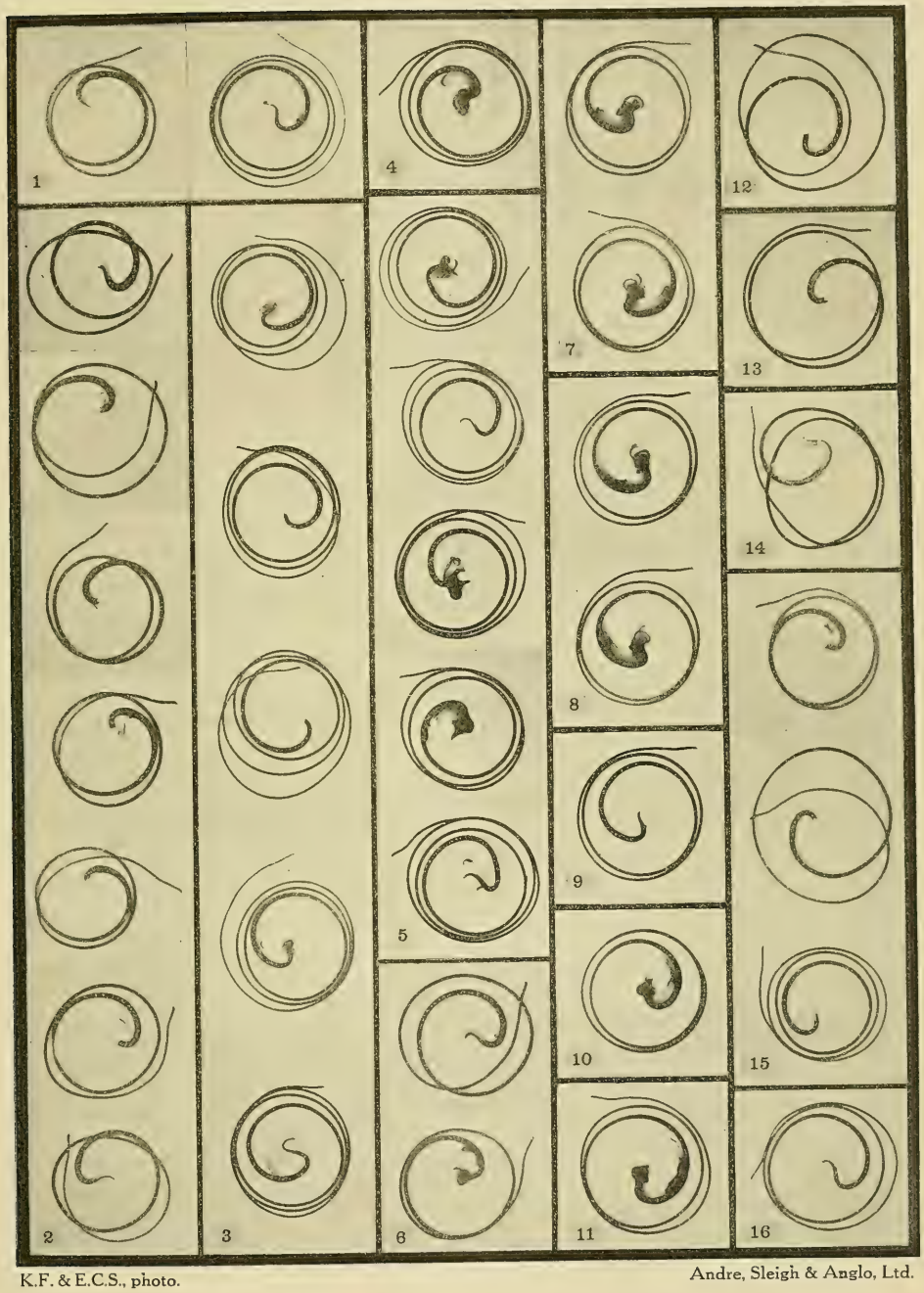
PHOTO 53. Intromittent organs from the four bugs of photo 53, plate 33. Lengths of intromittent organs :—1st (upper), 115½ mm. 2nd, 112 mm. 3rd, 115 mm. 4th, 143½ mm.

PHOTO 54. Intromittent organs from the four bugs of photo 54, plate 33. Lengths of intromittent organs :—1st (upper), 130 mm. 2nd, 120 mm. 3rd, 135 mm. 4th, 112 mm.

PHOTO 55. Intromittent organs from the four bugs of photo 55, plate 33. Lengths of intromittent organs :—1st (upper), 116½ mm. 2nd, 118 mm. 3rd, 118 mm. 4th, 131 mm.

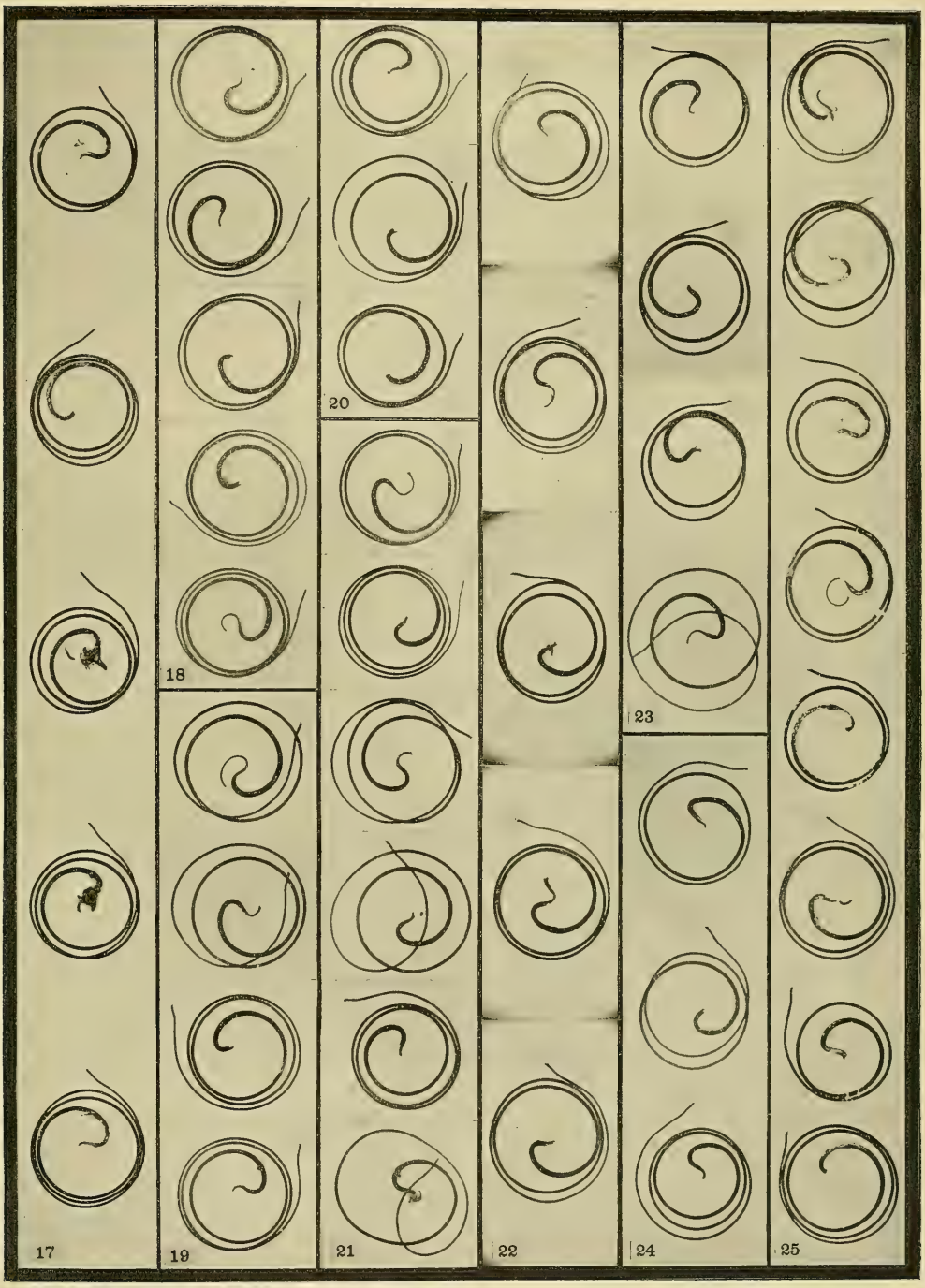
PHOTO 56. Intromittent organs from the three bugs of photo 56, plate 33. Lengths of intromittent organs :—1st (upper), 112½ mm. 2nd, 119 mm. 3rd, 129½ mm.

PHOTO 57. Intromittent organs from the two bugs of photo 57, plate 33. Lengths of intromittent organs :—1st (upper), 106½ mm. 2nd, 120 mm.



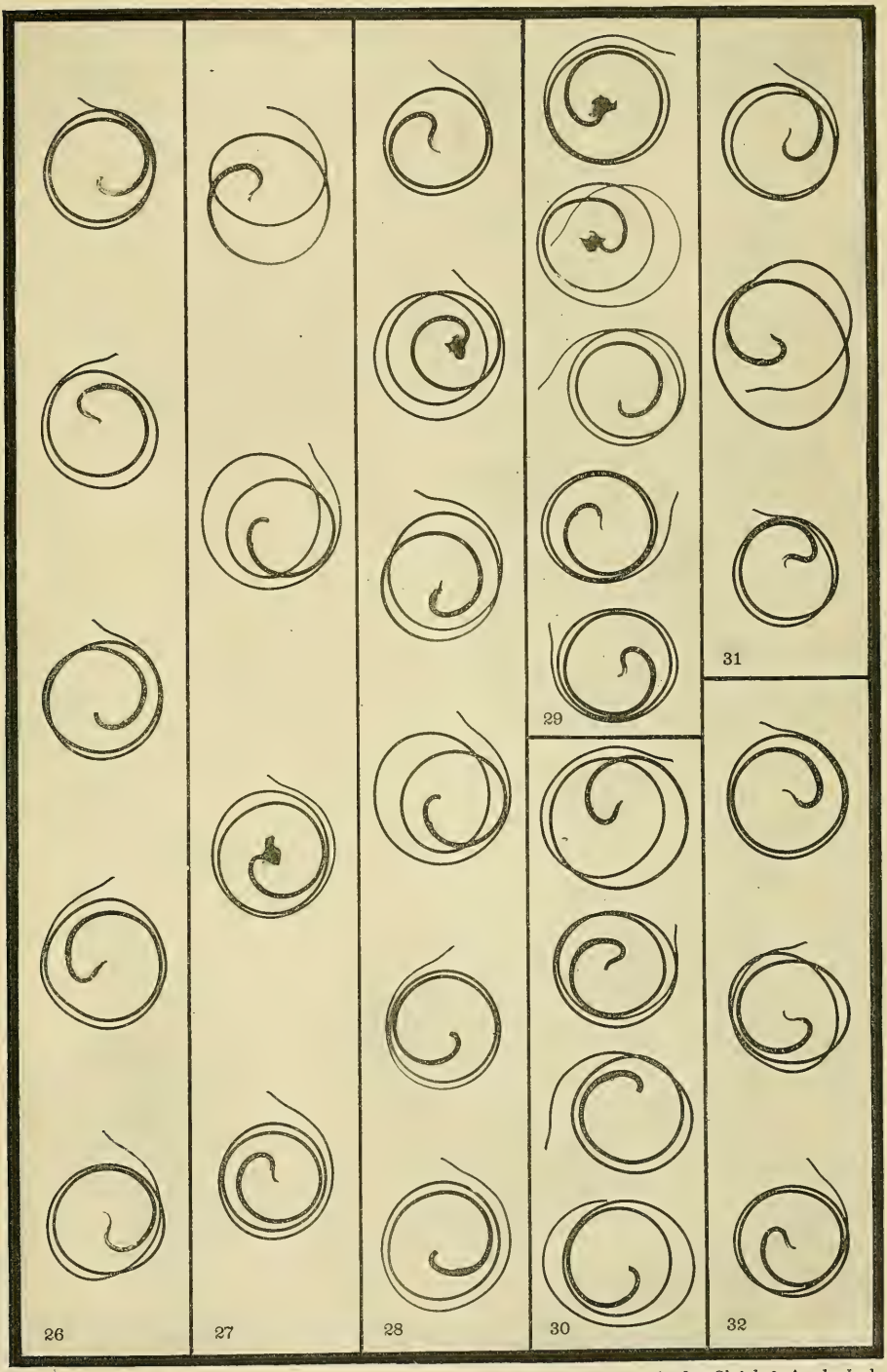
K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from EUSCHISTUS VARIOLARIUS, E. SERVUS, & HYBRIDS.



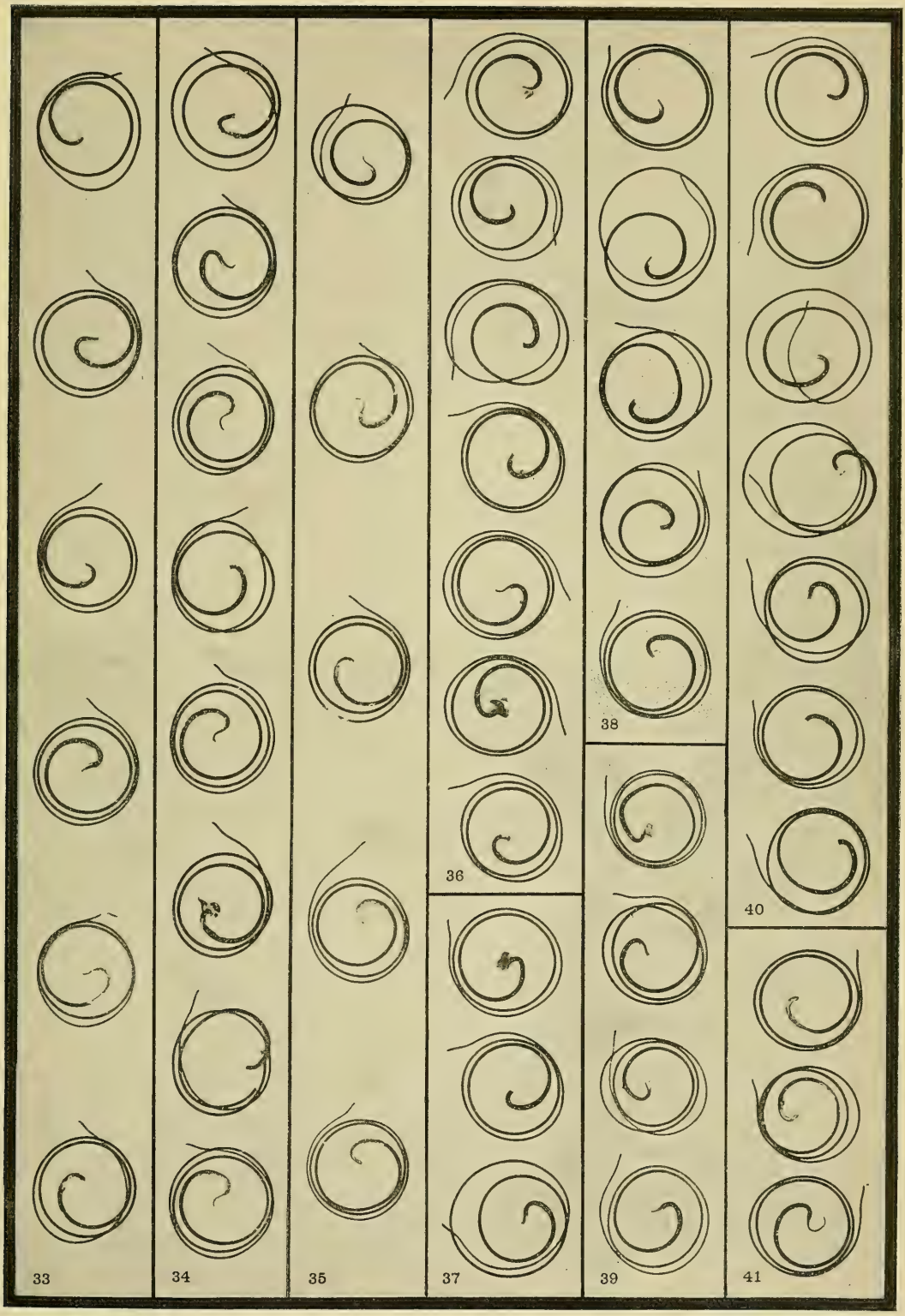
K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from F_2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



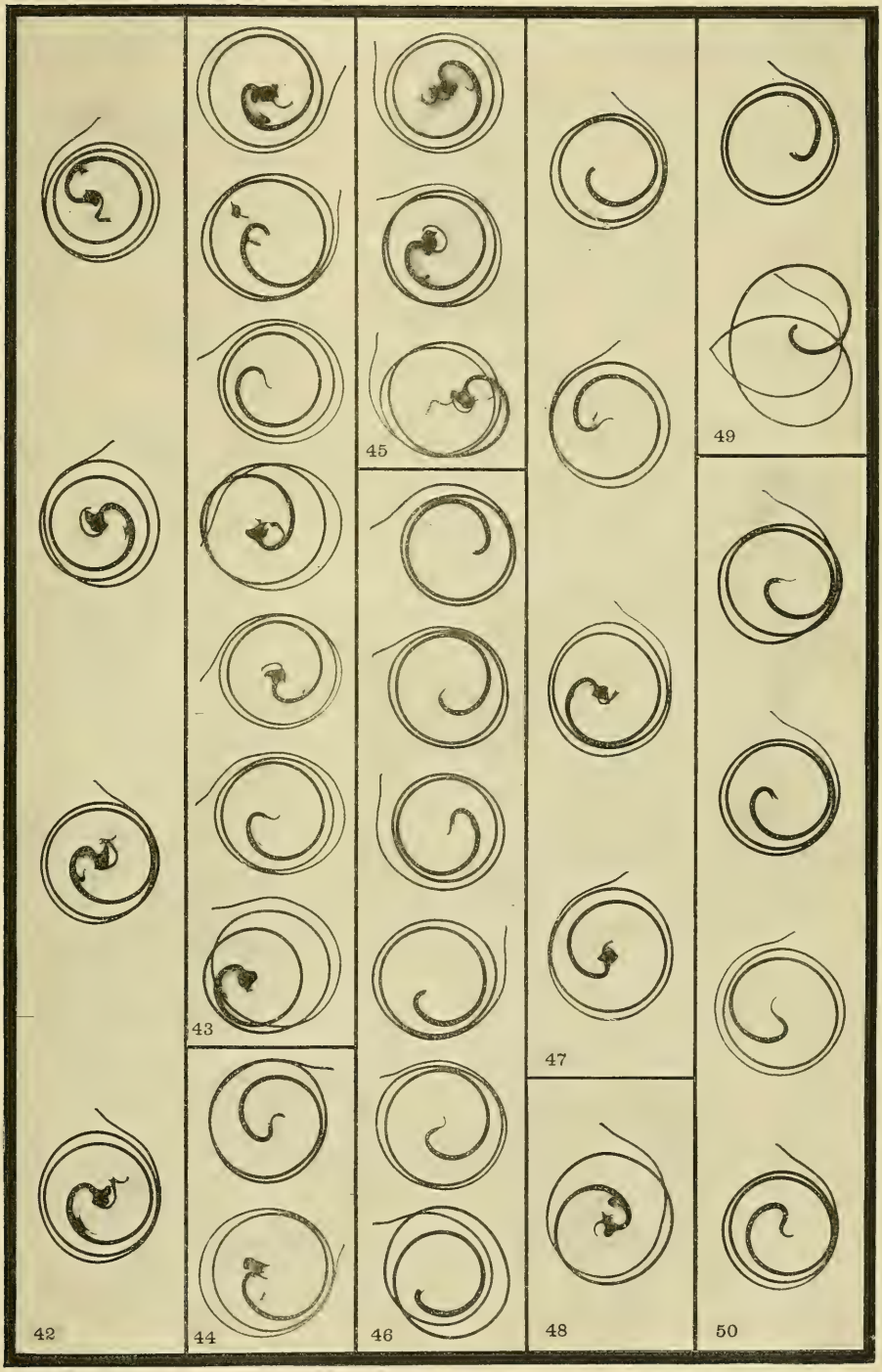
K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from F_2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



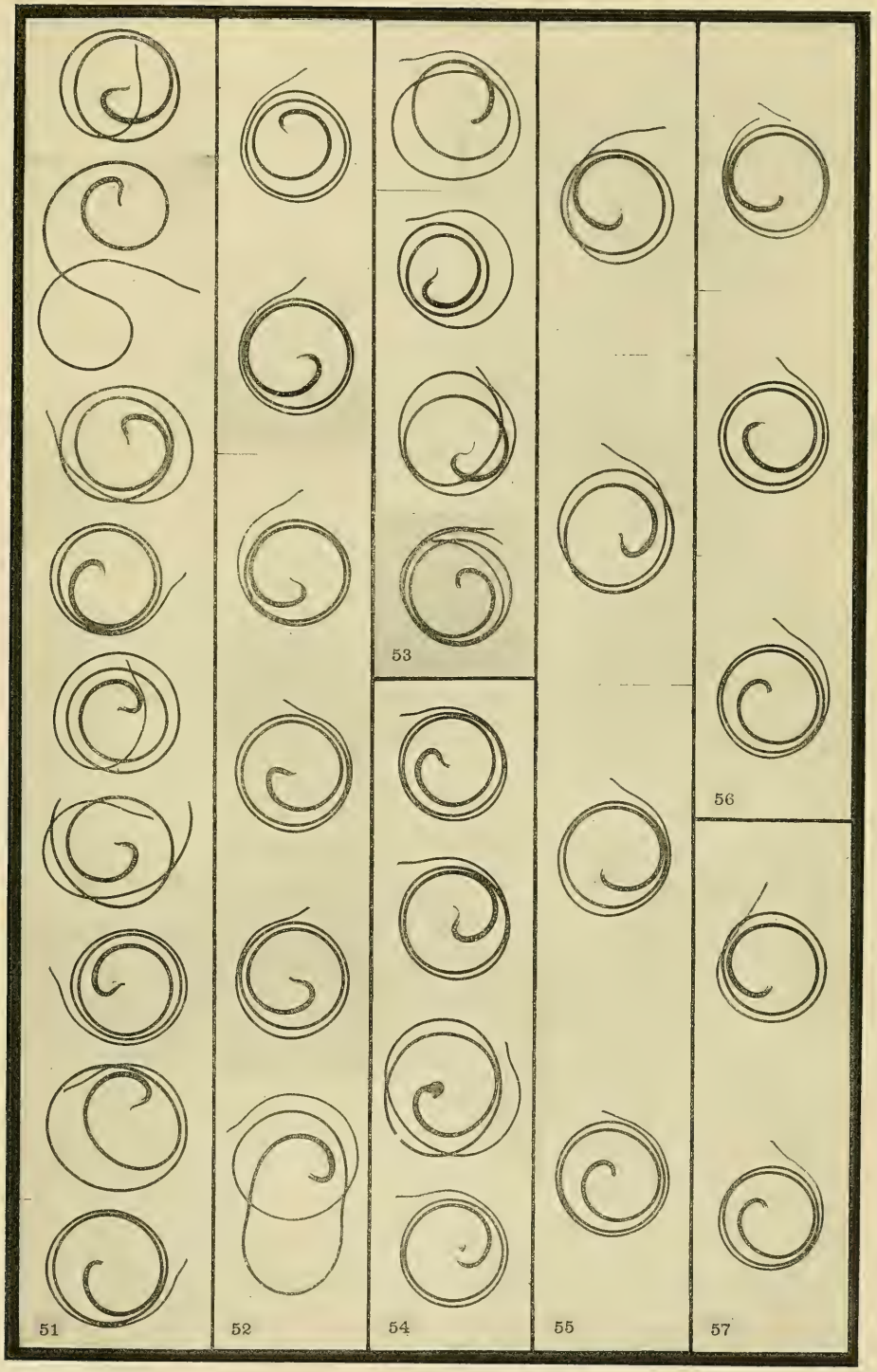
K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from F_2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



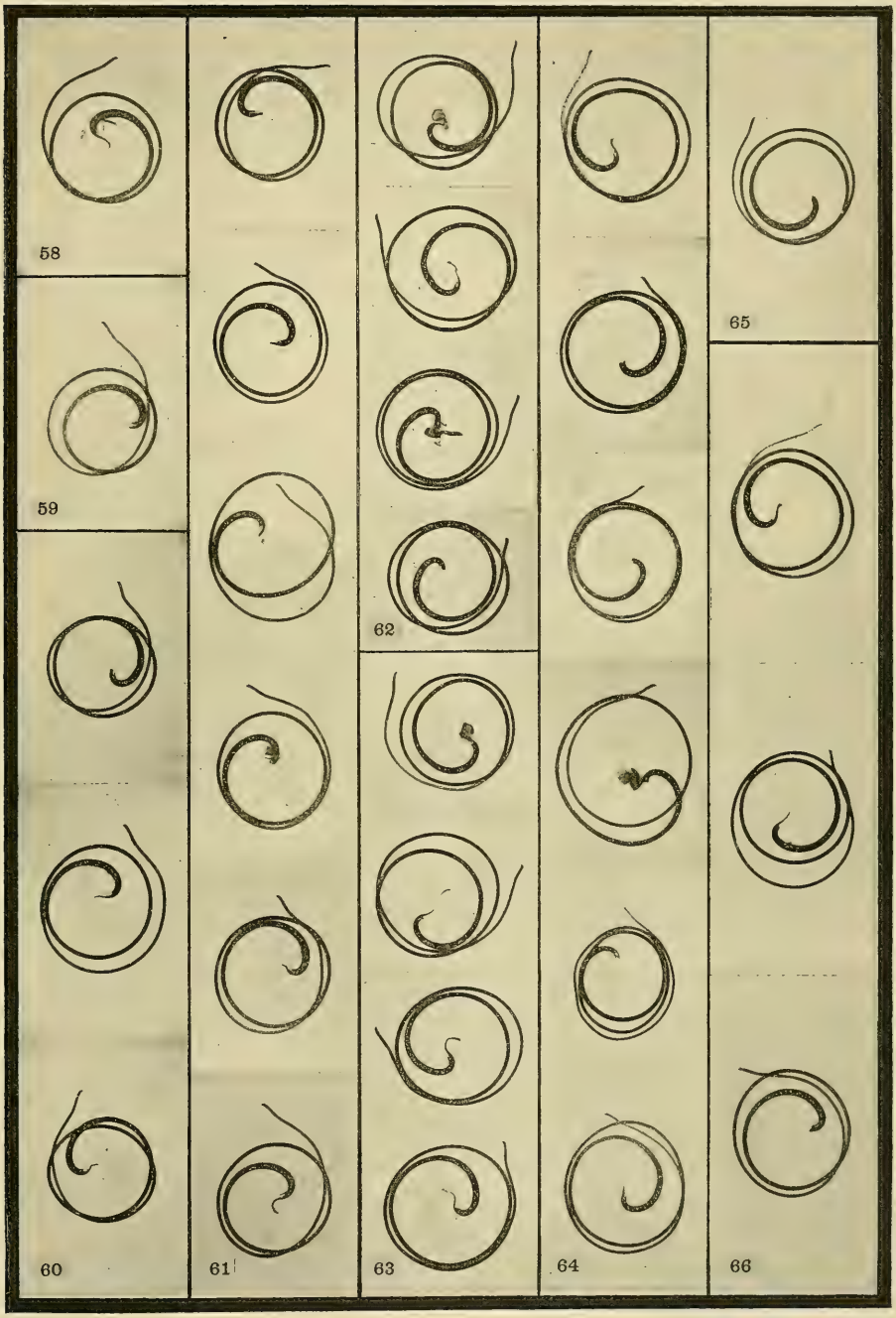
K.F. & E.C.S., photo. Andre, Sleigh & Anglo. Ltd.

INTROMITTENT ORGANS from F_2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from F_2 HYBRIDS from E. VARIOLARIUS & E. SERVUS.



K.F. & E.C.S., photo. Andre, Sleigh & Anglo, Ltd.

INTROMITTENT ORGANS from E. VARIOLARIUS MALES & MALES from F1 ♀ × E. VARIOLARIUS ♂

PLATE 47.

(*Cf.* Plate **34** of this volume.)

PHOTO 58. The intromittent organ from the pure *variolarius* of photo 58, plate 34. Length of intromittent organ, 94 mm. This pure *variolarius* male was raised in the laboratory in 1912, and the same season fertilized both a pure female *variolarius* and an F_1 hybrid female.

PHOTOS 59–61. Intromittent organs of 10 males from the above-mentioned pair of pure *variolarius*.

PHOTO 59. Intromittent organ of the male of photo 59, plate 34. Length of intromittent organ, 94 mm.

PHOTO 60. Intromittent organs of the three males of photo 60, plate 34. Lengths of intromittent organs:—1st (upper), 98 mm. 2nd, 100 mm. 3rd, 94 mm.

PHOTO 61. Intromittent organs of the six males of photo 61, plate 34. Lengths of intromittent organs:—1st (upper), 100 mm. 2nd, 100 mm. 3rd, 100 mm. 4th, 95½ mm. 5th, 102 mm. 6th, 98 mm.

PHOTOS 62–66. Intromittent organs of 18 males from the above-mentioned backcross (F_1 hybrid ♀ × pure *variolarius* ♂).

PHOTO 62. Intromittent organs from the four males of Photo 62, plate 34. Lengths of intromittent organs:—1st (upper), 112½ mm. 2nd, 105 mm. 3rd, 128½ mm. 4th, 117 mm.

PHOTO 63. Intromittent organs from the four males of photo 63, plate 34. Lengths of intromittent organs:—1st (upper), 110½ mm. 2nd, 116 mm. 3rd, 106 mm. 4th, 107 mm.

PHOTO 64. Intromittent organs from the six males of photo 64, plate 34. Lengths of intromittent organs:—1st (upper), 115 mm. 2nd, 112½ mm. 3rd, 122½ mm. 4th, 102 mm. 5th, 119 mm. 6th, 118 mm.

PHOTO 65. Intromittent organ from the male of photo 65, plate 34. Length of intromittent organ, 113½ mm.

PHOTO 66. Intromittent organs from the three males of photo 66, plate 34. Lengths of intromittent organs:—1st (upper), 114½ mm. 2nd, 116½ mm. 3rd, 106½ mm.

On a Collection of Thysanoptera from the West Indies, with Descriptions of new Genera and Species.

By Richard S. Bagnall, F.L.S.

(Plates 48 & 49; and 2 Text-figures.)

[Read 19th November, 1914.]

Some recent small collections of Thysanoptera from the West Indies have proved highly interesting, producing such noteworthy forms as *Corynothrips*, Williams, and *Dinurothrips*, Hood, the former described from St. Vincent and the latter from Porto Rico.

This present paper deals with a collection made by the Government Entomologist, Mr. Urich, in Trinidad, and though the species are few, yet they are of very considerable interest. Out of eleven species but six represent previously known forms, and of these *Frankliniella melanommata* has but recently been described (Dec. 1913) by Williams, whilst the Neotropical forms *Dicaiothrips lævicollis*, Bagn., *D. brevicornis*, Bagn., and *Eupathithrips silvestrii* (Buffa) are not well known. All the new forms are striking species, and I have found it necessary to erect three new genera—*Sedulothrips* (to which we must also refer Hood's *Polyommatothrips vigilans*), *Craniothrips*, and *Chirothripoides*. The latter is erected for an anomalous and peculiar form, the type of a new division of the Tubulifera; and, having now studied five species of *Eupathithrips* and the allied genus *Sedulothrips*, I have considered it expedient to form a division for their reception. The compressed and subcarinate dorsum of the head, the large finely-facetted eyes, almost contiguous in front, the subventrally or ventrally seated antennæ, and the long mouth-cone are typical of this group; whilst the form of antennæ and the long sense-cones are also peculiar, the latter originally suggesting the generic name *Eupathithrips*. In describing *Polyommatothrips vigilans* from Panama, Hood * has pointed out that the strongly emarginate fore-margin of the prothorax enables the head to be moved back to an angle of about 45 degrees. The antennæ are inserted on the ventral surface and must be carried in life at almost right angles to the head—hence the necessity of the abnormal moving back of the head. Mr. J. D. Hood has very generously forwarded me his unique ♂ and ♀ types of this interesting insect for examination and comparison with my Trinidad example, which is a very closely allied species. I have thus had an opportunity of studying all the known species of this group, and append a few further remarks upon *Eupathithrips dentipes*, which still rests upon the type-specimen collected by Mr. Champion. I should

* 'Psyche,' xx., August 1913, p. 123.

mention that the Bromeliaceous species, *Eupathithrips affinis*, was collected by Mr. Hugh Scott, to whom I am indebted for the single specimen, and I trust that renewed search in its apparently specialised habitat will result in the discovery of more examples.

In raising the *Eupathithrips* group and *Chirothripoides* each to family rank, I do so reluctantly and provisionally; that they are sharply separated from the heterogeneous *Phlœothripidæ* (s. l.) is evident, but it will only be after the examination of a great deal more material and a close analysis of our known forms that we can hope to put the Tubilifera upon a sound working basis. Meantime, by recognizing and setting aside these well-defined groups, we, by elimination, make work upon the residue a little more easy.

As a mark of gratitude and esteem, I have pleasure in naming *Craniothrips urichi* in Mr. Urich's honour.

Suborder TEREBRANTIA.

Family ÆOLOTHRIPIDÆ.

Subfamily ÆOLOTHRIPINÆ.

Genus MITOTHRIPS, *Trybom*, 1912.

Near *Æolothrips* and allies, and readily distinguished by the extraordinarily long and slender antennæ caused by the elongation of joints 3 and 4, which are apparently without sensoria or sense-areas of any kind. Fore-wings without cross-veins, broadened distally.

Eyes larger, ocelli normal. Antennæ at least 6 times as long as the head, joints 2–4 light; 4 longer than 3, and 5–9 together only 0·2 the length of 3 and 4 together *Mitothrips megalops*, Trybom.

Eyes smaller, front ocellus smaller than others. Antennæ about 3·5 times as long as head, joints 1–4 light; 4 shorter than 3, and 5–9 together more than one-half (0·57) the length of 3 and 4 together *Mitothrips petulans*, sp. n.

MITOTHRIPS PETULANS, sp. n. (Pl. 48. figs. 1–5; Pl. 49. figs. 1 & 2.)

♀. Length a little more than 2·0 mm., breadth of pterothorax 0·31 mm.

General colour dark brown, mesothorax lighter, and abdominal segments 1 to 3 white or yellowish-white, excepting where joined to each other, and there tinged with reddish-brown; segment 10 light yellow. Antennal joints 1–4 light lemon-yellow, tip of 4 lightly tinged with brown, 5–7 dark brown, and 8 and 9 lighter greyish-brown. All femora lighter or darker brown, inclined to a yellowish light patch near apices within; fore-tibiæ yellowish to greyish-brown, margins dark brown, hind and intermediate tibiæ uniformly dark brown; all tarsi whitish. Fore-wings rich brown, a clear ill-defined patch occupying third fifth, or thereabouts, and a similar

but shorter white area just before the distal twelfth ; hind wings clear, with a faint trace of grey corresponding with the dark areas of the fore-wing.

Head and thorax difficult to describe from the single preparation owing to the extreme difficulty in obtaining an exact dorsal view. Head more or less subglobular in form, cheeks roundly constricted to base, with a few small setæ. Eyes irregularly and somewhat coarsely facetted, some of the facets beneath being extraordinarily large ; facets not touching ; minutely pilose ; upper portion occupying about 0·5 the length of head. Posterior ocelli somewhat large, placed above a line drawn across the posterior fourth of eyes ; anterior one much smaller, protected by two long bristles placed rather closely together on a line across the front of posterior pair. A pair of short dorsal setæ on a line behind eyes, approximately behind the posterior ocelli. Antennæ very long and slender, about 3·5 times as long as the head, pilose ; basal joints subapproximate ; 2 cylindrical, twice as long as broad ; 3 with short stem, about 15 times as long as broad ; 4 also long and slender, a shade broader than 3 and about 9 times as long as broad ; 5 to 7 slightly broader ; 8 rapidly narrowing from about middle, distally and broadly united to 9, which is almost styliform. Relative lengths of joints—12 : 17 : 80 : 55 : 25 : 18 : 16 : 14 : 5·5. Palpi 3/2-jointed. Head ventrally arcuate below insertion of antennæ and furnished with numerous hairs, the inmost pair the longest.

Prothorax apparently not broader than the head and converging basally, about as long as the head and 0·8 as long as broad across fore-angles ; no prominent bristles and surface irregularly, sparsely, and minutely setose. Pterothorax long and narrow, 1·25 times as long as wide, broadest across base of mesothorax, where it is twice as broad as at juncture with prothorax ; sides roundly widened, and sides of metathorax narrowed to base, 0·65 as wide across posterior coxæ as across mesothorax. Legs long, setose, the setæ arranged in more or less regular rows, femora thickening distally ; structure of fore-tarsus typically Æolothripid. Wings reaching to about the 7th abdominal segment ; fore-wing broadened distally, rounded at tip, longitudinal veins indistinct but clearly defined by setæ ; cross-veins absent. Costal bristles slender, 35, ending at extreme apex ; whole length of upper vein with 22 and hind vein with 16 short setæ—more widely spaced on central clear patch, none on distal clear patch, and 2+2 on distal dark area. Cilia on fore-margin of hind-wing sparse, only a little longer than the breadth of the wing ; those forming lower fringes of both fore- and hind-wings long.

Abdomen subpetiolate, very narrow at juncture with thorax, broadening evenly to 6th segment, where it is 1·5 times as broad as the pterothorax and more than 2·5 times as broad as the posterior margin of 1. 9 abruptly narrowed to base of 8, and 8 and 9 roughly obconical ; 9 with one long lateral bristle near middle and two pairs of similar bristles on posterior

margin of tergite, which are longer than segments 9 and 10 together and dark brown in colour. Tergite 10 with four long colourless bristles, about 0·75 the length of those on 9; two shorter ones at extreme tip (vestigial segment 11).

Type. In Hope Collections, University Museum, Oxford.

Habitat. Trinidad, Sangre Grande, July 1913. Associated with *Heliothrips rubrocinctus* on cacao-leaves.

In many respects, especially in the form of body, this species reminds one of *Franklinothrips vespiformis*, Crawf., from which it may be distinguished by the form of antennæ and head, coloration of abdomen, the first three and 10th segments of which are light in this species.

Family Thripidæ.

Genus Heliothrips, *Hal.*

Heliothrips hæmorrhoidalis (*Bouche*) and var. abdominalis, *Reut.*

44 ♀'s and larvæ on Liberian Coffee; Esparanza Estate, California, Trinidad, Oct. 1912; on under sides of leaves, also on upper side when well shaded (99·4).

4 ♀'s f. *typica* only and larvæ on coconut-leaves, Cocal, East Coast, Trinidad, July 1913 (99·6).

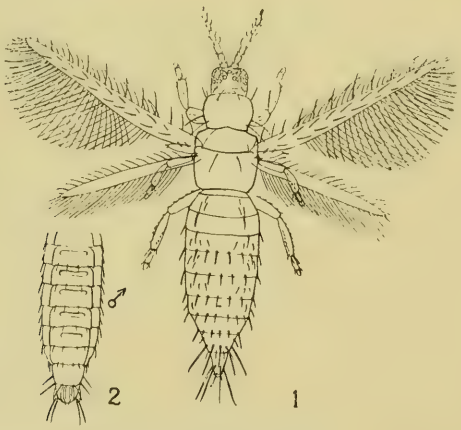


Fig. 1.—*Frankliniella insularis* (Franklin). × 20.
2.—The same; underside of abdomen in ♂. × c. 20.

Genus Frankliniella, *Karny.*

Frankliniella insularis (*Franklin*), *cf. Proc. U.S. Nat. Mus.* xxxiii. (1908) 715.

Both sexes of this species, described by Franklin from Barbados, are well represented in two tubes, one from flowers of *Erythrina* (7 ♀'s, 1 ♂, and

larvæ), Sangre Grande, Feb. 1913 (99·7), and the other from cultivated roses, sucking petals, La Tosca, Sangre Grande, April (99·5) and November 1913. In the latter case the species appeared in numbers and was accompanied by *Frankliniella melanommata*, Williams.

It is also known from Guadalajara and Monterey, Mexico; Brownsville, Texas; and Miraflores, Canal Zone, Panama *.

Frankliniella melanommata, *Williams*, *Journ. Econ. Biol.* vol. viii., December 1913, pp. 213–215, fig. 2.

This little species has only recently been described by Williams from St. Vincent. It is somewhat closely allied to *tritici* (Fitch) and *cephalicus*, Crawford, and it causes one to think that the *tritici* recorded by Franklin from Barbados may be referable to this form.

Both sexes from cultivated roses, La Tosca, Sangre Grande, April and November 1913.

Suborder TUBULIFERA.

Family Idolothripidæ.

Dicaiothrips lævicollis, *Bagn.*

Two ♀s with *D. brevicornis* recorded below, and 3 ♂s and 1 ♀ from Verdant Vale, Trinidad, April 1912. These agree perfectly with description of the original examples from Venezuela, except in the length of the bristles of the 9th abdominal segment in the ♂, which in these examples are seven-eighths the length of tube. It should be noted that these are shown much too short in the original figure (pl. 52. fig. 5 †). The relative lengths of the antennal joints are approximately :—20 : 26 : 102 : 63 : 57 : 45 : 28 : 25. Tube in ♂ about 4 times as long as broad at base.

Dicaiothrips brevicornis, *Bagn.* (Pl. 48. fig. 9.)

Examples of both sexes found amongst leaves of a dead coconut-palm and some on and under the bark of the stem. Mr. Urich states that examples were observed to deposit eggs on the leaves and to sit over them. The fore-femur within has a low tubercle at distal third, somewhat as in *Idolothrips tuberculatus*, Hood, though not so pronounced.

♂. The male was previously unknown. The head is a little longer than in the ♀, nearly 2·5 times as long as broad, postocular bristles absent, and genal spines a little more plentiful. Fore-femora not strongly incrassate; spines on outer side near base stronger than in the ♀; tibiæ and tarsus as in ♂ *distinctus*, Bagn. Relative lengths of antennal segments approximately :—18 : 25 : 66 : 51 : 45 : 35 : 24 : 22.

* See Hood, 'Psyche,' xx. No. 4, August 1913.

† Journ. Linn. Soc., Zool. xxx. 1909, pp. 369–387, pls. 51–53.

Abdominal segments 7 and 8 practically subequal. Tube stout, 0·7 as long as head, twice as long as 9th segment, and but slightly longer than either 7 and 8; about 3 times as long as broad at base and twice as broad at base as at apex. Terminal hairs about as long as tube, those on 9 a little longer.

This species fits well into Section II. ii. B of my table on Neotropical *Dicaiothrips*, wherein these two species were described, but is readily separated from both *lævicollis* and *foveicollis* by the short third antennal joint and stout tube.

Family Eupathithripidæ, mihi.

Head at least twice as long as wide; dorsum compressed and subcarinate, Eyes finely and closely facetted, prominent, contiguous, or nearly touching anteriorly, almost completely surrounding ocelli; ventrally well separated. Cheeks with or without prominent spiniferous tubercles. Mouth-cone long and pointed, reaching to beyond the base of the prosternum. Antennæ set below vertex, on ventral surface; intermediate joints long and slender, segments 3 to 5 (or 6) clavate, distally abruptly narrowed; sense-cones very long and slender.

Cheeks with prominent spiniferous tubercles. Antennæ set higher on the ventral surface, sense-cones longer, third joint shorter than or at most but little longer than 4. Fore-femur in both sexes with a tooth near apex within. Genus Eupathithrips, Bagn.

Cheeks without tubercles. Antennæ set lower on the ventral surface; sense-cones shorter; third joint much longer than 4; anterior margin of prothorax strongly emarginate. Fore-femur simple.... Genus Sedulothrips, nov.

Genus Eupathithrips, *Bagnall*.

1908. *Eupathithrips*, Bagnall, Trans. N. H. Soc. Northumberland, Durham, and Newcastle-upon-Tyne, n. s., iii. p. 23.
1908. *Heterothrips*, Buffa (not Hood), "Redia," iv. 1908, p. 124.
1909. *Polyommatothrips*, Buffa, *op. c.* v. 1909, p. 164.

[Eupathithrips dentipes, *Bagn.* 1908. (Pl. 48. fig. 10; Pl. 49. fig. 5.)

This species is easily separated from *silvestrii* and *affinis* by its larger head, the larger fore-legs, the distinctive shape of fore-femora (as in *Rhœbothrips*, Karny) which are without the minute spiniferous tubercles on the inner margin, and the strong double series of teeth-like protuberances along the inside margin of tibia. The abdomen is broader, and the segments 4–7 at least have a white patch at each anterior angle.

The prothorax is not so triangular in shape as shown in my original figure, but I find it difficult to describe from the single dried specimen.]

Eupathithrips affinis, sp. n. (Pl. 48. fig. 11 ; Pl. 49. figs. 6 & 8.)

♂. Length about 4·5 mm.

Colour as in *E. silvestrii*, but with the apical *two-thirds* of intermediate tibiæ and apical *half* of hind tibiæ yellow. Abdominal segments 3 to 6 each with a pair of antero-lateral white patches.

Relative lengths of antennal joints 3–8 as follows:—163 : 168 : 174 : 110 : 73 : 36. Sense-cones protected by long pointed setæ as in *E. dentipes*.

This species differs from *E. silvestrii* in its smaller size, the relative lengths of antennal joints 3 and 4 (which in this species are practically subequal), and in the coloration of the intermediate and hind tibiæ. The genal spine just behind eyes is more minute than in *silvestrii*, whilst the genal spiniferous tubercles and those along the inner margin of each fore-femur are noticeably larger than in the ♂ of that species. The two series of tubercles along inner margins of fore-tibiæ, so strong in *dentipes*, and in *silvestrii* vestigial, are in *affinis* distinctly denoted.

Though a smaller species, the prothoracic setæ (at least the mid-lateral and anterior pairs) are distinctly longer than in *silvestrii*, the shortest being at least 0·4 the length of the prothorax.

The bristles of the 9th abdominal segment are longer than in *silvestrii*, the outer being about as long as the tube and the inner distinctly longer, whilst the lateral abdominal bristles are comparatively longer also.

Type. In Hope Collections, University Museum, Oxford.

Habitat. Trinidad, 1 ♂, taken by Mr. Hugh Scott from between the leaf-bases of an epiphytic Bromeliaceous plant, from the virgin forest of Trinidad's highest mountain, Tucuché, 3100 feet, March 20th, 1912.

Eupathithrips silvestrii (*Buffa*). (Pl. 48. fig. 12 ; Pl. 49. figs. 7 & 9.)

Heterothrips silvestrii, Buffa, 'Redia,' iv. 1908, pp. 124–125, fig. 2.
Polyommatothrips silvestrii, Buffa, *op. c.* v. 1909, p. 164.

♀. Length 5·0 to 5·5 mm., breadth of mesothorax about 0·7 mm.

Colour dark chestnut-brown ; fore-tibiæ yellowish shaded lightly with brown near base, intermediate and hind tibiæ with the distal half and fifth respectively yellow ; all tarsi yellow. Antennal joint 3 yellow, lightly touched with brown near apex ; stems of 4 and 5 and basal third of 6 similarly yellow.

Head 2·2 times as long as broad, and 2·5 times as long as prothorax through middle ; cheeks with a few prominent spiniferous tubercles and a short stout spine near eyes. Eyes practically touching anteriorly, very finely facetted, occupying about one-third the length of head. Ocelli rather large, and almost completely surrounded by the eyes ; anterior ocellus forwardly directed. Postocular bristles short and blunt, placed far back, about one-

third the length of the eye. Antennæ nearly twice as long as the head, set ventrally below the anterior part of the eyes, and between the ventral parts; relative length of joints :—54 : 50 : 134 : 165 : 165 : 96 : 64 : 32; 3–6 produced distally into a shorter or longer stem beyond the broadest part, the produced part being longer and more slender in 5 and 6; 7 and 8 broadly and obliquely united, together fusiform. Sense-cones exceptionally long and slender, protected immediately behind by short, slender, knobbed setæ, instead of long bristles as in the known allied forms. Mouth-cone long and sharp, reaching beyond pronotum.

Prothorax 2·25 times as long as broad across hind angles, anterior margin rather strongly emarginate; setæ rather short, parallel-sided and faintly expanded at tips; the longest (at posterior angles) from 0·35 to 0·4, and the others about 0·32 the length of prothorax.

Pterothorax as broad as long, surface, especially the metanotum medially, more or less plainly reticulated. Wings reaching to about the 6th abdominal segment, tinged with smoky yellow, darker near base, and median thickenings and cilia brown. Median vein in fore- and hind-wings reaching to the distal fourth; cilia on both margins long and closely set, at least 32 duplicated at posterior margin of fore-wing near apex.

Fore-femur very slightly incrassate, with tooth near apex within and a few minute spiniferous tubercles on inner margin; fore-tibiæ with a double row of short bristles their basal tubercles being vestigial; fore-tarsus with a minute tooth in both sexes.

Abdomen long and slender, slightly narrower than pterothorax at base, and narrowed evenly to base of tube, all segments, excepting 9, distinctly transverse. Tube 0·5 the length of tube, about 0·4 as broad at base as long and 0·45 as broad at apex as at base; terminal hairs slender, about 0·7 the length of tube. Bristles on 9th segment about as long as tube, the outermost pair slightly shorter and more slender; 7 and 8 with two pairs of blunt dorso-lateral bristles, the outer being the longer, colourless; 2–6 with similar but shorter bristles, which are dark brown at base and colourless distally. In addition, there is a shorter sharp spine at extreme posterior angles of 3–8. Wing-retaining spines on 2–6, and one vestigial pair at hind margin of 7.

♂. A little smaller and more slender; genal spines not so noticeable. Ninth tergite with a pair of spines placed above the posterior margin and between the inner and outer bristles; outer pair of bristles slender, about 0·7 the length of tube, inner ones about as long as the tube.

There can be little doubt that this is the species described by Buffa, the short third antennal joint and the minute protecting hairs of the sense-cones being distinctive features shown in Buffa's figure.

Habitat. Trinidad, on and in cracks of a dead cacao-tree (*Urich*).

Genus Sedulothrips, nov.

Cheeks without tubercles. Antennæ set low on the ventral surface of head, between the eyes; joint 3 longer than 4; sense-cones moderately long, shorter than in *Eupathithrips*. Anterior margin of prothorax strongly emarginate. Fore-femur without tooth near apex within.

Otherwise as in *Eupathithrips*.

Sedulothrips insolens, sp. n. (Pl. 48. figs. 13–15; Pl. 49. fig. 10.)

♀. This species so closely approaches *S. vigilans*, Hood *, that a detailed description is unnecessary. The fore-tibiæ are unicolorous with the femora; the antennæ are of a darker shade, yellowish-brown, and the stems of joints 4 to 6 are not so markedly yellowish as in *vigilans*, these joints being practically unicolorous; and the 6th joint is more fusiform and longer than the apical and penultimate joints together. The prothorax is broader, at least 2·5 times as broad as its median length; all bristles present, blunt, and longer than in *vigilans*, those at posterior angles at least 0·5 the median length of the prothorax, and those at anterior angles and the mid-lateral pairs not shortened as in *vigilans*.

The fore-wings are of a uniform brown with slight yellowish tinge and, if anything, richer in colour basally; median thickening (which almost attains apex in hind-wing) darker brown. Fore-wings darker in colour than in *vigilans*, not strikingly lighter distally, and without the clear patch near base; surface distally curiously sculptured, giving the appearance of being set with scales; 27 cilia duplicated.

Abdominal segment 8 longer than the tube (in ♀ *vigilans* not so long). Distal half of tube not noticeably lighter; hairs on segment 9 2·6 (in ♀ *vigilans* 2·0) times the length of tube, and outer terminal hairs just twice the length, the innermost pair shorter.

Through Mr. Hood's kindness, I have had the satisfaction of examining the ♂ and ♀ types of his *Polyommatothrips vigilans*. I was at first tempted to regard my solitary example as referable to *vigilans*, but it differs in so many little points (of which the chætotaxy of the prothorax and the 9th abdominal segment and tube, the coloration, and curious sculpturing of the fore-wings seem to be the most important) that it seems necessary to regard it as belonging to a second species.

I hope that further examples will be met with, so as to make a closer examination of these points possible, and more especially of the curious surface-structure of the fore-wings.

Type. In the Hope Collections, University Museum, Oxford.

Habitat. Trinidad. One ♀ with *Eupathithrips silvestrii*, Buffa, from on and in cracks of a dead cacao-tree.

* 'Psyche,' xx., August 1913, p. 123.

Family Phlœothripidæ (s. l.).

Genus Craniothrips, nov.

Size small. Head twice as long as broad, arched dorsally. Mouth-cone not reaching across prosternum, blunt, rounded at tip ; maxillary palpi long and stout. Prothoracic setæ stout, blunt ; the single long bristle on each fore-coxa pointed. Fore-wings slightly constricted at about middle.

Belongs to the *Haplothrips-Hindsiana* group, but distinguished at once by the shape of the head, which reminds one in a modest way of the arched head of that curious genus *Docessissophothrips*, Bagn.

Type. *C. urichi*, mihi.

Craniothrips urichi, sp. n.

Length 1·8–1·9 mm.

General colour lemon-yellow to a richer yellow ; antennal joints 5–8 grey-brown, and distal half of 4 lightly tinged with grey ; lower median margin of mesonotum and corresponding upper portion of metanotum and the whole of the tube grey-brown. Wings clear, with a grey-brown patch at base; fore-wing with the second third (*i. e.* middle portion) grey-brown, and hind-wing with corresponding portion slightly tinged with grey ; cilia dark. Tip of mouth-cone and a spot at tip of each tarsus brown.

Head twice as long as broad across eyes and 1·5 times as long as the prothorax, dorsal surface arched and sides somewhat constricted near base. Eyes coarsely facetted, occupying approximately 0·25 the length of head, pigmentation deep black. Vertex raised in form of a hump ; ocelli large, posterior pair on sides of raised part, almost contiguous with eyes and above a line drawn across their centre ; the anterior one facing forwards ; pigmentation crimson. Interocular bristles absent. Postocular bristles present, placed well back and about the length of an eye, stout, practically parallel-sided and broadened at tip. Mouth-cone reaching about 0·7 across prosternum, blunt; tip rounded. Maxillary palpi long and stout, basal joint very short; one sensory filament at tip longer than the others and than the palp, an additional filament on the inner margin near apex. Antennæ at least 1·6 times the length of the head, approximate at base and seated below the vertex ; relative length of joints:—12 : 19 : 21 : 21 : 20 : 29 : 18 : 14. Sense-cones normal; last joint with an apical sense-bristle as long as the joint.

Prothorax about 1·25 times as broad across hind-angles as long, diverging from base of head to about middle and thence practically parallel. Bristles at anterior and posterior angles and postero-marginal and mid-lateral pairs present, each of the latter pair being set just behind and close to the ones at anterior angles ; those at posterior margin about 0·5 as long as the

prothorax, all stout and broadened at apex. Fore-coxæ projecting, with one long, slender, and *pointed* bristle ; fore-femur 0·8 the length of the head and about twice as long as broad ; tibia about as long as femur ; tarsus unarmed. Prothorax a little longer than broad and only slightly broader than the breadth across fore-coxæ. Fore-wing very slightly constricted about middle, with three stout setæ, similar to those on the prothorax, at base ; cilia on fore- and hind-margins somewhat long and widely spaced.

Abdomen only slightly broader than pterothorax, about 3·5 times as long as broad, practically parallel-sided, thence gently rounded to base of tube. Tube about 0·6 the length of head, 0·4 as broad at base as at apex ; sides evenly and gently narrowed. Terminal hairs greyish-brown basally, colourless distally ; longer than tube, but very slender and difficult to see. Bristles on 9th segment slender and about as long as the tube. Lateral bristles long, tapering, an inner pair stouter and knobbed.

Type. In the Hope Collections, University Museum, Oxford.

Habitat. Trinidad, Capara, August onwards, 1913. On leaves of *Inga* sp.

Family Chirothripoidiidæ, mihi.

Genus Chirothripoides, nov.

Size small. Form very slender and linear.

Head longer than broad, produced beyond eyes ; ocelli on or above a line across the fore-margin of eyes. Mouth-cone short, rounded. Maxillary palpi 2-jointed, apical sensory filaments very long. Antennæ with joints 3 to 5 at least as broad as long.

Prothorax weakly chitinised, longer than head and longer than broad. Fore-coxæ very elongate, all legs short and stout ; fore-tarsus armed. Pterothorax elongated ; wings long, very slender, and practically parallel-sided from base to apex ; long cilia on both margins of fore- and hind-wings.

Abdomen linear ; posterior margin of 8th sternite armed with a pair of long lateral spines and a series of four shorter pairs between them, the inmost being longest.

Type. *C. typicus*, mihi.

The form of the antennæ, head, prothorax, wings, and, in particular, the curious armature of the 8th sternite make it difficult to place the species in any of the recognized Tubuliferous groups, and for the present I regard it as standing alone.

Chirothripoides typicus, sp. n. (Pl. 48. figs. 6–8 ; Pl. 49. figs. 3, 4.)

♀. Length 1·4 mm., breadth of mesothorax 0·175 mm.

Colour light yellowish- or greyish-brown. Ninth abdominal segment

yellowish. Head and antennæ rather darker, with 2nd joint faintly lighter. Fore-femur yellowish, all tibiæ yellow, lightly tinged with grey. Wings light grey-brown, lightest basally.

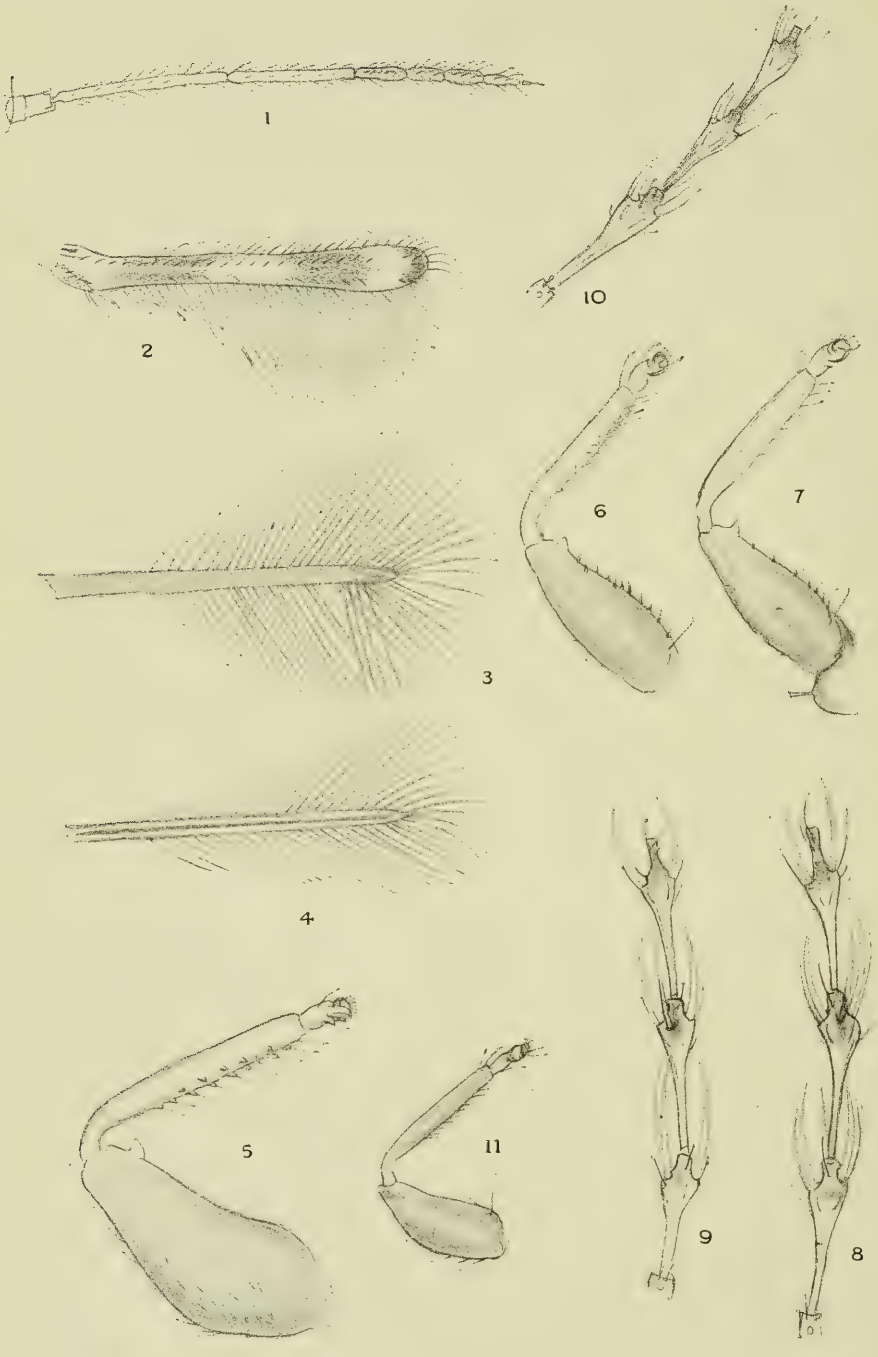
Head very narrow, about 1·6 times as long as broad and only 0·75 the total length of the prothorax ; produced beyond eyes. Eyes long, occupying about 0·55 the length of the head, and somewhat close together at their inner margins near middle. Ocelli large, especially the posterior pair, which are widely separated and situated close to the anterior margins of the eyes ; fore-ocellus placed near insertion of antennæ. Cheeks practically parallel, short, occupying only 0·27 the length of the head ; produced part about 0·7 the width across eyes, the whole of the front being occupied by the insertion of the antennæ. Antennæ almost touching at base, about twice as long as the head ; joints 3 and 4 broader than long ; relative lengths of joints approximately 10 : 13 : 11 : 10 : 11 : 12 : 12 : 13, formed as in Pl. 48. fig. 6. Sense-cones on segments 3 to 6, short and rather stout, only 1 on 6. Mouth-cone short and rounded, reaching only about one-third way across prosternum ; maxillary palpi short, with one of the sensory filaments at apex longer than the palpus.

Prothorax apparently not strongly chitinous, almost as long as broad, broadest at posterior third, where it is about 2·5 times as broad as the head ; narrowed evenly from anterior third to juncture with the head. Only one pair of noticeable bristles at a position indicative of the posterior angles. Prosternum with a long median impression or line. Pterothorax about 1·75 times as long as broad. Posterior coxæ closer together than the other pairs. Fore-femur rather long and broad, intermediate and hind femora and all tibiæ short and stout ; fore-tarsus with a stout tooth. Wings reaching to about the 7th abdominal segment, both pairs curiously narrow and parallel-sided ; fore-wing about twenty times as long as broad near middle ; hind pair with a median vein running well down towards apex. Cilia long, rather widely spaced, with 4 duplicated near apex of posterior margin in the fore-wing.

Abdomen long and linear, about 0·6 the total length of the insect, and five times as long as broad across the 8th segment. Eighth segment produced at each hind angle of the sternite in the form of a long sharp spine, inwardly directed and curved and reaching to the base of the tube ; posterior margin of sternite armed with 4 shorter pairs in addition to the lateral teeth, the innermost pair being the longest and stoutest. Posterior margin of 8th tergite simple. Tube short and stout, about 0·8 the length of the head and about 0·6 as broad at base as long ; apical hairs not as long as tube, very weak distally.

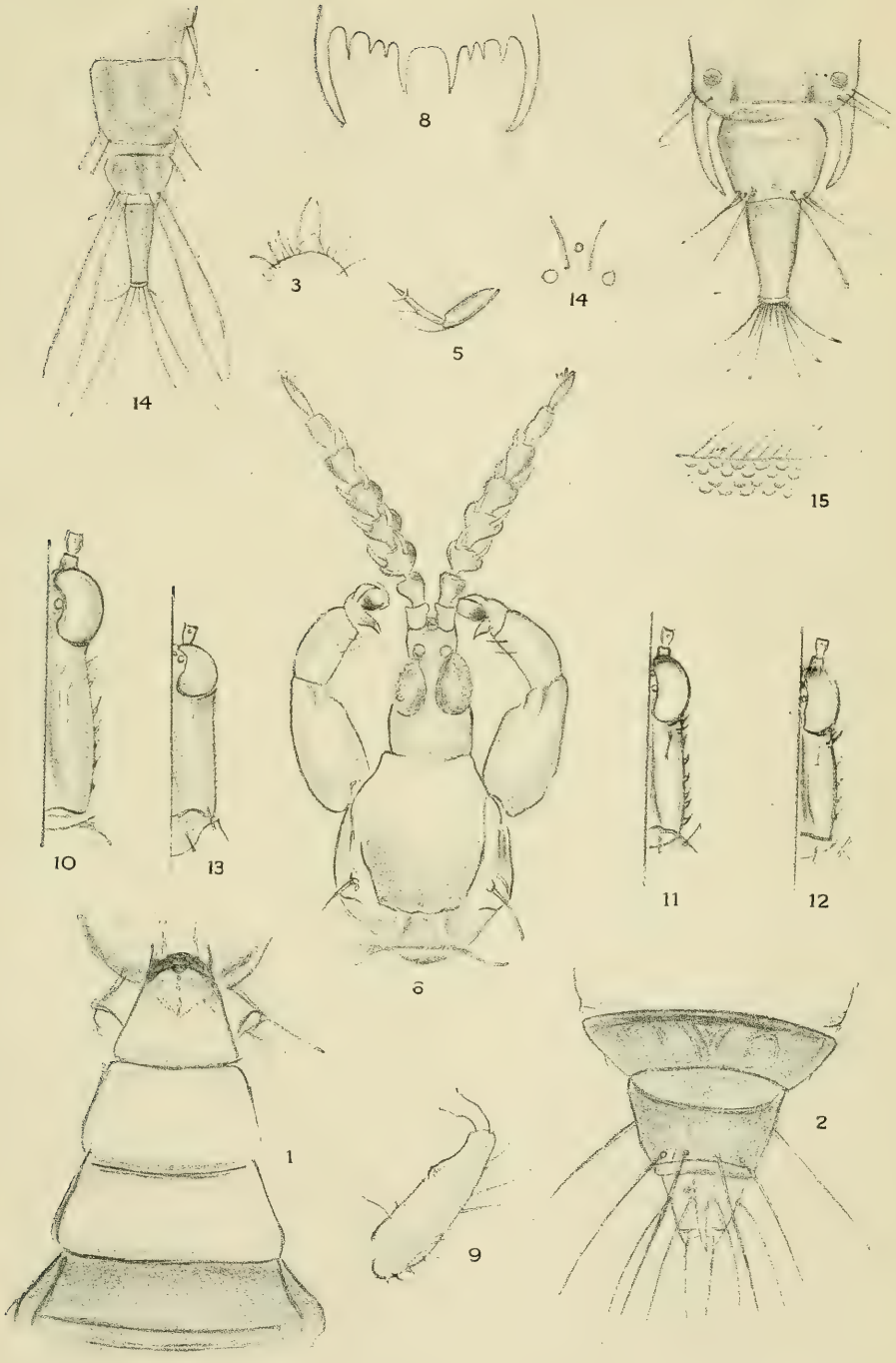
Type. In the Hope Collections, University Museum, Oxford.

Habitat. TRINIDAD, Arima, Verdant Vale. Taken on a window, to which they were blown by strong wind.



R. S. B. del. Grout, sc.

TRINIDAD THYSANOPTERA.



R. S. B. del. Grout, sc.

TRINIDAD THYSANOPTERA.

EXPLANATION OF THE PLATES.

Plate 48.

Fig. 1. *Mitothrips petulans*, sp. n., ♀. Abdominal segments 1–4, × 80.
2. „ „ „ „ „ 8–10, × 80.
3. „ „ „ Outline of frons, × 80.
4. „ „ „ Ocelli, × 80.
5. „ „ „ Maxillary palpus, × 120.
6 *Chirothripoides typicus*, gen. et sp. n., ♀. Prothorax, fore-legs, head, and antennæ, × 60.
7. „ „ „ End of abdomen, × 60.
8. „ „ „ Posterior margin of the 8th abdominal segment (ventral), ×80.
9. *Dicaiothrips brevicornis*, Bagnall. Right fore-femur, × 45.
10. *Eupathithrips dentipes*, Bagnall. Right side of head, × 45.
11. „ *affinis*, sp. n., ♂. „ „ × 45.
12. „ *silvestrii* (Buffa), ♀. „ „ × 45.
13. *Sedulothrips insolens*, sp. n., ♂. „ „ × 45.
14. „ „ „ End of abdomen, × 45.
15. „ „ „ Sculpturing of right wing near apex, × c. 120.

Plate 49.

Fig. 1. *Mitothrips petulans*, sp. n., ♀. Right antenna, × 80.
2. „ „ „ Right fore-wing, × c. 40.
3. *Chirothripoides typicus*, sp. n., ♀. Right fore-wing, × 40.
4. „ „ „ Right lower wing, × 40.
5. *Eupathithrips dentipes*, Bagnall. Left fore-leg, × 45.
6. „ *affinis*, sp. n., ♂. „ „ × 45.
7. „ *silvestrii* (Buffa), ♀. „ „ × 45.
8. „ *affinis*, sp. n., ♂. Joints 3–5 of left antenna, × 80.
9. „ *silvestrii* (Buffa), ♀. „ „ „ × 80.
10. *Sedulothrips insolens*, sp. n., ♂. Left fore-leg, × 45.

Description of a new Genus and Species of Terrestrial Isopoda from British Guiana.

By Walter E. Collinge, M.Sc., F.L.S., F.E.S., Research Fellow of the University of St. Andrews.

(Plate 50.)

[Read 4th March, 1915.]

The Terrestrial Isopoda of the South American continent have as yet received very little attention, although one cannot help thinking that there is a large and interesting fauna awaiting investigation. From different parts, species have been described by Miers (1), Budde-Lund (2), Dollfus (3, 4, 5, 6), and Richardson (7), but in all probability these constitute only a very small part of the actual indigenous fauna.

Some few months ago Mr. G. E. Bodkin, the Government Economic Biologist at Georgetown, Demerara, British Guiana, very kindly forwarded to me for identification a number of specimens collected beneath the bark of trees in the Botanic Gardens, Georgetown. Two of the specimens (both imperfect) are referable to the cosmopolitan species *Porcellionides pruinosus* (Brandt), whilst the remaining ones, in various stages of growth, belong to a new genus and species here described under the name of *Calycuoniscus bodkini*.

Calycuoniscus, gen. nov.

Body oblong-oval, flattened; metasome a little narrower than the mesosome, the cephalon and segments covered with peculiar cup-shaped or calyx-like organs, and the appendages marked with lattice-work and scale-like ornamentation. Cephalon with well-developed median and lateral lobes, the former being prolonged forwards and slightly downwards; epistoma raised in the median line, at each side of which is a deep concavity. Antennæ of medium length with 3-jointed flagellum, divisions subequal. Uropoda extending beyond telson, globose, basal plate with raised anterior margin; exopodite short and thick, outer border almost straight; endopodite same length as exopodite, both setaceous with terminal hair-like setæ. Telson triangular with posterior margin bluntly rounded.

Affinity doubtful.

Calycuoniscus bodkini, sp. nov.

Body (fig. 1) oblong-oval, flattened; metasome a little narrower than the mesosome, the segments of both, and also the cephalon, covered with peculiar

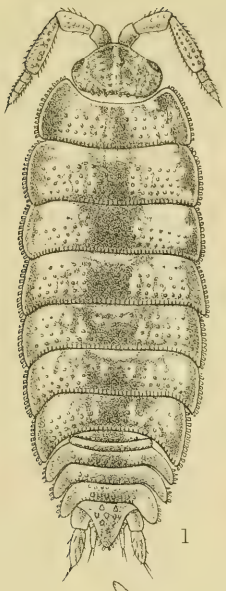
cup-shaped organs (fig. 2). Appendages marked with lattice-work-like ornamentation (fig. 9). Cephalon (figs. 3 & 4) convex above and with numerous cup-shaped organs, median and lateral lobes conspicuous ; epistoma raised in the median line with two lateral concavities. Eyes prominent, situated dorso-laterally almost above the cup-shaped lateral lobes of the cephalon. Antennulæ 3-jointed. Antennæ (fig. 5) of medium length, the 5th joint being the longest ; flagellum 3-jointed, with subequal divisions and terminal style. 1st maxillæ (fig. 6), outer lobe terminating in four large curved spines and four small ones with bifid terminations. The segments of the mesosome are somewhat flattened, the lateral plates of the 1st partly surround the cephalon, all have their posterior angles slightly produced and overlap one another, fringed with numerous cup-shaped organs. Maxillipedes (fig. 7) with the outer palp terminating in a large multispinous process and two smaller inner spines with broad bases ; the inner palp has two marginal tooth-like spines. Thoracic appendages (fig. 8) comparatively short, ornamentation strongly marked, densely covered with setæ and spines, and terminating in strong claw. Uropoda (figs. 10 & 11) somewhat globose, basal plate with anteriorly raised margin, external antero-lateral margin produced inwards slightly ; exopodite short and thick, outer border almost straight ; endopodite same length as exopodite, articulating beneath the anterior raised margin of the basal plate, both setaceous and with terminal hair-like setæ. Telson (fig. 12) triangular with posterior margin bluntly rounded. Length 2·8 mm. Colour (in alcohol) horny-brown with darker lateral portions or with dark median line.

Habitat. Beneath the bark of trees, Botanic Gardens, Georgetown, Demerara, British Guiana.

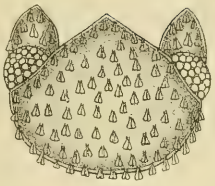
Type. In collection of W. E. C.

This species is of special interest, in that it possesses a very peculiar series of chitinous organs on the body-segments and cephalon. In the spirit-preserved examples they do not exhibit any structure beyond that shown in figure 2, viz., a cup-shaped organ with a tube-like body in the centre. Dollfus (4) has figured some similar bodies on the telson of *Platyarthrus* (?) *simoni*, Dollfus, from Venezuela, and Budde-Lund (8) describes and figures very similar ones on the telson and metasome of another Venezuelan species, *Trichorhina quisquiliarum* (B.-L.). His brief description is as follows :—"margo posterior omnium segmentorum serie papillarum minutissimarum ornatus."

The form of the cephalon is unlike that in any other genus I am acquainted with, the eyes being being very prominent and situated almost above the cup-shaped lateral lobes, whilst the median lobe is prolonged forwards and slightly downwards. The two lateral concavities on the epistoma are also characteristic.

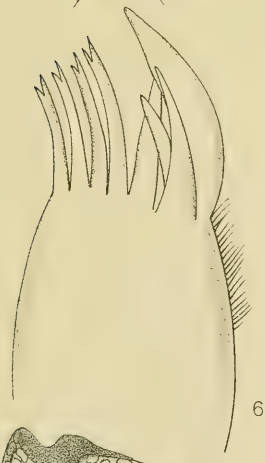

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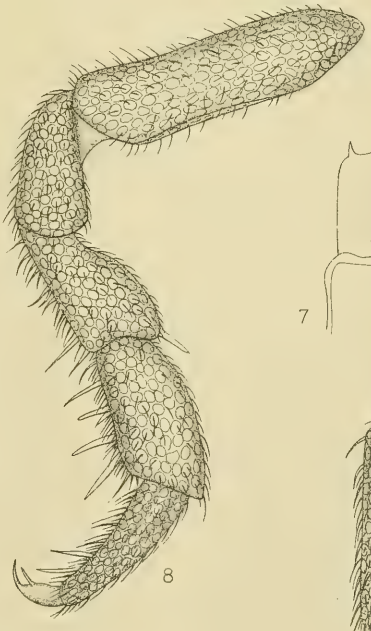

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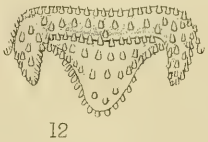

12

Fig 1 E. Wilson
Figs. 2-12 E.W.E. & W.E.C. del.

Cambridge University Press.

ISOPOD FROM GUIANA

In addition to the above-mentioned cup-shaped organs, the whole of the body and the appendages are marked with a scale-like or lattice-work ornamentation. This is particularly prominent on the ischiopodite of the thoracic appendages (fig. 9).

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EXPLANATION OF PLATE 50.

Calycuoniscus bodkini, gen. et sp. n.

Fig. 1. Dorsal view. ×24.
2. Cup-shaped bodies on the cephalon and body-segments.
3. Dorsal view of the cephalon, tilted upwards anteriorly to show the median and lateral lobes. Colour-markings not shown.
4. Anterior view of the cephalon.
5. Antenna.
6. Terminal portion of the outer lobe of the 1st maxilla.
7. Terminal portion of the right maxillipede.
8. Second thoracic appendage.
9. Pattern of ornamentation on the ischiopodite of the 2nd thoracic appendage.
10. Right uropod, ventral surface.
11. „ „ dorsal surface.
12. Telson and last metasomatic segment.

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A Description of Five new Species of *Edwardsia*, Quatr., from New Guinea, with an Account of the Order of Succession of the Micromesenteries and Tentacles in the Edwardsidæ.

By Gilbert C. Bourne, M.A., D.Sc., F.R.S., F.L.S.

(Plate 51, and 2 Text-figures.)

[Read 6th April, 1916.]

For some time past I have been working out the anatomy of a collection of Anthozoa made some years ago by Dr. A. Willey in New Guinea. My apologies are due and are hereby tendered to him for not having undertaken this work sooner. For one reason or another it was put aside; but, when I began to give serious attention to it some eighteen months ago, I found that the collection included several forms of great interest, one of which I have already described. Among the specimens were five species of the genus *Edwardsia*, which form the subject of the present short memoir, and a number of other forms which appear to be related to, but can hardly be included in, the subfamily Phelliinæ. It was my intention to give a full and detailed description of the anatomy and histology of these forms, and I had expected to bring my work to a conclusion by the end of last summer. But my time has been taken up since the beginning of August by numerous interests arising from the European war, and, at the time of writing, I am about to leave Oxford for service in the Army. As my investigations on the Edwardsiæ were nearly complete, and the results partly written out in full, it has seemed desirable to put together, in however hurried a manner, such parts of my projected memoir as seem worth publishing as a preliminary notice. I have not been able, in the short time at my disposal, to give an account of my observations on the anatomy and histology of the species I have studied, and this must be deferred to a future publication. The present paper is confined to a description of the five species collected by Dr. Willey in New Guinea, and to an account of the sequence of the development of the tentacles and micromesenteries in the Edwardsiæ.

The genus *Edwardsia*, de Quatrefages, has been the subject of much discussion among actinologists in recent years, and has successively been raised to the rank of an ancestral type and degraded to the position of a degenerate offshoot of the dodecamerous Actinians. It was originally described by de Quatrefages (23), O. & R. Hertwig (15), and Andres (1) as having eight, and only eight, mesenteries, of which the muscle-banners are arranged on a plan exactly resembling that of the first four couples of protocnemes of Actinians and Corals. This feature attracted the special

notice of Boveri (5) and McMurrich (18, 19, 20) ; and these two authors, by ingenious and convincing arguments, showed that the various plans of mesenterial sequence exhibited by the Cerianthidæ, Zoanthidæ, Antipatharia, Madreporaria, and Actiniidea could be derived from the Edwardsian type, and claimed that the existing Edwardsidæ are to be regarded as the ancestral type from which all the groups enumerated have been evolved. But in 1895 Faurot (10) showed that, in addition to the large macromesenteries with conspicuous muscle-banners, a variable number of micromesenteries, confined to the upper region of the capitulum, and so small as to have escaped previous notice, exist in the two species *E. beautempsii* and *E. adenensis*. In the former species the positions of the micromesenteries could be compared with the arrangement seen in *Halcampa*, and it was therefore no longer possible to regard *Edwardsia* as an ancestral type. The late Prof. Ed. van Beneden discussed the relationships of the Edwardsidæ in his splendid memoir on the Anthozoa of the Plankton Expedition (3), and argued that they are Hexactinarians simplified by progressive regression of the mesenteries of the second cycle and of the fifth and sixth mesenterial couples of the first cycle. He added : " Au surplus il faut renoncer à voir dans les Edwardsiés le type ancestral d'où seraient issus les Hexactiniaires." Van Beneden's view of the relationship of the Edwardsidæ has been generally adopted, and for the last eighteen years they have been classified among the Actiniaria, and as early as 1898 Carlgren (8) classified them together with the Halcampomorphidæ in his subtribe Athenaria, which corresponds very nearly to the family Ilyanthidæ of Gosse.

It is not possible for me, at the present juncture, to enter into a discussion of the very debateable questions of the classification of the Anthozoa. It is sufficient for me to state that I accept the principle of Carlgren's (9) division of the Anthozoa into the three subclasses Hexacorallia, Octocorallia, and Dodecacorallia, but cannot reconcile myself to the use of the names proposed. Carlgren's Hexacorallia includes the Cerianthidæ and the Antipatharia, and is equivalent to van Beneden's group Ceriantipatharia. The classification seems a natural one, but as the Actinians and Corals have long been known as Hexactiniæ and it is now desired to insist on the separation of the Cerianthidæ from these forms, Carlgren's choice of a name seems to me unfortunate and liable to cause confusion. The Ceriantipatharia of van Beneden are a subdivision of the " Scyphactiniaria," a subclass including the Scyphomedusæ and Rugosa. In my opinion there are valid reasons for excluding the Scyphomedusæ from the Anthozoa, and the position of the so-called " Rugose " Corals is still uncertain. I am inclined to use van Beneden's name of an order, Ceriantipatharia, for the name of a subclass, identical with Calgren's Hexacorallia and equivalent in rank to the Octactiniaria and Zoanthactiniaria. The last name is van Beneden's, and is equivalent to Carlgren's Dodecacorallia. The sub-

class includes the orders Zoantharia, Carlgren (= Zoanthinaria, van Beneden), and Hexactiniaria, van Beneden, the last-named comprising the Actiniaria and Madreporaria. As it is the purpose of this paper to show that the Edwardsidæ have not the character of six pairs of first-cycle mesenteries indicated by the names "Hexactiniaria" and "Dodecacorallia," I cannot accept either Carlgren's name for the subclass or van Beneden's name for the order which is to include the Edwardsidæ. I think that van Beneden's name, Zoanthactiniaria, may well stand for the subclass named Dodecacorallia by Carlgren. This subclass, according to my opinion, comprises three orders—the Edwardsiaria, the Zoanthinaria (= Zoantharia, Carlgren), and the Dodecactiniaria, the last-named comprising the suborders Actiniaria and Madreporaria, or, as I have called them in another place (4), and still prefer to call them, the Malacactiniæ and Scleractiniæ.

It is the object of the latter part of this paper to justify my opinion that the Edwardsiaria form a group distinct from, and of equal rank with, the Zoanthinaria and the Dodecactiniaria.

I. *Description of new Species.*

Subclass ZOANTHACTINIARIA, van Bened.

Order EDWARDSIARIA, mihi.

Family EDWARDSIDÆ, Andres.

Genus EDWARDSIA, de Quatrefages.

EDWARDSIA MAMMILLATA, n. sp. (Plate 51. fig. 1.)

Body clearly divided into capitulum, scapus, and physa. Scapus about four-fifths of the entire length of the animal, covered by a thick olive-green epidermis, transversely wrinkled, studded with eight longitudinal rows of elevated semi-transparent tubercles of various sizes; the largest tubercles mammilliform and situated at about a quarter of the whole length of the scapus from the capitular end, thence diminishing in size towards the physa; the tubercles intermesenterial in position. Capitulum when contracted about one-twentieth the length of the scapus, colourless in spirit, its surface divided into eight intermesenterial areas by shallow grooves corresponding to the insertions of the macromesenteries; its upper border thickened and raised into ten more or less triangular elevations which, in a contracted specimen, overhang the edge of the infolded oral disc and alternate with the bases of the tentacles. Physa about as long as the capitulum, acorn-shaped, tapering posteriorly, colourless, transversely wrinkled, without epidermis or tubercles, with a terminal depression resembling a terminal pore. Tentacles ten in number, short, conical, in contraction infolded over the oral disc.

Macromesenteries eight, with well-developed parietal muscles and moderately well-developed longitudinal retractor muscles; the mesoglœal folds forming the muscle-banners 10–13 in number, slightly branched. Micromesenteries two, one in each lateral macromesenterial interspace, small, without retractor muscles, confined to the capitulum.

Length of contracted specimen, 13–14 mm.; diameter, 1 mm.

Hab. Ile du Phare, Nouméa, New Caledonia.

Edwardsia rugosa, n. sp. (Plate **51**. fig. 2.)

Body divisible into capitulum, scapus, and physa. The capitulum not distinctly marked off, finely wrinkled transversely, with eight longitudinal shallow furrows corresponding to the insertions of the macromesenteries, covered with a very thin epidermis. The scapus coarsely wrinkled transversely and covered with warty tubercles somewhat irregularly arranged in eight longitudinal rows, the tubercles in the upper part of the scapus tending to form double rows, and some scattered in the intervening areas between the rows. The whole scapus invested by a thin bright ochreous-brown epidermis. The physa globose, colourless, without epidermis, with a very distinct terminal depression resembling a terminal pore.

Length, 35 mm.; greatest diameter, 3 mm.

Hab. Sariba, China Straits, British New Guinea.

The single specimen on which this species is founded had apparently undergone a considerable amount of decomposition before being placed in spirit. The external characters were fairly well preserved, but the internal organs, the tentacles, oral disc, and actinopharynx were so much macerated that I was unable to count the tentacles, to recognize any micromesenteries, or determine the extent and characters of the actinopharynx. The macromesenteries were so far recognizable in sections that I could determine the existence of the eight "Edwardsian" mesenteries with well-developed parietal muscles, and large muscle-banners with the characteristic orientation. In the débris of the tissues I could distinguish a few ova. The animal was therefore sexually mature, and there can be no doubt that it is a member of the genus *Edwardsia*. The colour and consistency of the thin friable epidermis, the nature of the transverse rugæ of the scapus, and the arrangement of the tubercles in irregular longitudinal rows offer sufficiently distinct characters to justify my describing this specimen as a separate species. The globose physa is also a marked feature, and, as is shown in fig. 2, it presents a circular and rather deep terminal depression; but I could not find any evidence in longitudinal sections of a pore leading into the cœlenteron.

I think I am correct in describing the finely-wrinkled slightly-swollen upper end of the specimen as a capitulum; it is fairly distinctly marked off from the rest of the scapus, but it may be only a somewhat modified upper

part of the scapus. There was no other structure at the oral end that I could identify as a capitulum ; but the tissues within the involuted oral end were so much macerated that it was impossible to come to a definite conclusion on the matter.

EDWARDSIA VERMIFORMIS, n. sp. (Plate **51**. fig. 3.)

The animal vermiform, tapering towards the oral extremity, thickest in the middle and tapering again towards the posterior extremity, where it expands rather abruptly to form the large, ovoid, thin-walled physa. No distinguishable capitulum. The two tapering ends of the scapus marked with eight longitudinal shallow grooves corresponding to the insertions of the macromesenteries, and furrowed at intervals by transverse wrinkles so regularly disposed as to give an appearance of segmentation ; the thicker middle portion of the scapus devoid of longitudinal furrows and transverse wrinkles. The whole scapus covered by a thin, very minutely wrinkled, yellowish-brown epidermis, easily rubbed off and showing a slaty-grey mesoglœa below. The physa thin-walled, saccular, compressed, without longitudinal and transverse grooves. Colour in spirit : scapus a dirty olive-grey, physa a dull orange.

Length, 36 mm. ; greatest diameter, 5 mm.

Locality. Uvea, Loyalty Islands.

The single specimen on which the above description is founded was in an even worse state of preservation than *E. rugosa*. I could find no trace of tentacles, oral disc, or actinopharynx in sections. The eight macro-mesenteries were partially preserved, and I was able to identify the muscle-banners, which were evidently large, with complicated much-branched mesoglœal folds. The swollen condition of the middle third of the body is due to the presence of the large muscle-banners. The physa was flattened and surrounded by a deep fold, which was probably due to compression in packing. When dilated, the physa must have been of unusually large size in proportion to the rest of the animal. There are no verrucæ visible to the naked eye on the scapus ; but examination with a lens and sections showed that many of these highly characteristic Edwardsian structures are scattered over the areas between the longitudinal grooves of the scapus. There is no doubt that this specimen is an *Edwardsia*, very different from the other species in Dr. Willey's collection, and I cannot refer it with certainty to any described species, so I describe it provisionally as a new species. It is somewhat similar to Klunzinger's (**16**) figure of *E. pudica*, Klg., but the physa of the latter is much narrower and tapers towards the posterior extremity. This difference may be due to the different states of contraction of the animals from which his figure and mine were drawn, and it is possible that the two species may eventually prove to be identical.

Edwardsia rakaiyæ, n. sp. (Plate 51. fig. 4.)

Scapus sepia-brown in colour, divided into eight longitudinal areas by as many well-marked grooves, corresponding to the insertions of the eight macromesenteries. The whole scapus irregularly rugose or papillate, the rugæ and papillæ forming indefinite transverse rows; the papillæ smaller in the grooves, larger in the longitudinal areas between, where they have a warty appearance and are minutely studded with greenish-white vesicles. The distal fifth of the scapus introversible. Capitulum very short, colourless in spirit, with twenty faint longitudinal grooves corresponding to the insertions of the macro- and micromesenteries. Physa oviform, colourless, without longitudinal grooves and raised intervening areas, separated by a well-marked constriction from the scapus. Tentacles twenty in number, colourless in spirit, 6–7 mm. long in contracted condition, tapering, in contracted specimens usually infolded and crowded together in the bottom of the invaginated part of the scapus, but some may be wholly or partially invaginated. The tentacles in two circlets—the inner comprising eight, the outer twelve tentacles.

The eight macromesenteries extend from the oral disc to the physa; their longitudinal retractor muscles are enormously developed in the region of, and immediately below, the actinopharynx, where they form eight prominent muscular rolls, but tapering rapidly aborally and ending in thin strands in the physa. Micromesenteries minute, confined to the capitulum, incomplete, with parietal but without longitudinal retractor muscle-fibres, twelve in number, two in each sulco-lateral, lateral, or sulculo-lateral intermesenterial interspace. The actinopharynx short, without a differentiated sulcus or sulculus. A distinct band-shaped endodermic sphincter muscle at the junction of the capitulum and physa.

Length of contracted specimen, 76 mm.; length of the physa, 5 mm.; greatest diameter, 10 mm.

Hab. Straits of Rakaiya, New Britain.

The three specimens of this species were fairly well preserved, and I was able to study the anatomy in some detail, both by dissection and in sections. But, owing to the contraction of the very powerful retractor muscles, all the specimens were burst and their shape more or less altered and distorted. In all of them a longer or shorter section of the scapus was introverted, in addition to the capitulum, this being a normal occurrence in *Edwardsia* and described by Gosse for *E. beautempsii* (*callimorpha*, 11, p. 257). In the specimen selected for illustration (Pl. 51. fig. 4) the scapus has given way a short distance below the point of introversion, and the lower portion has shrunk back, leaving a portion of the inner wall of the introverted portion exposed. In the two other specimens the scapus had given way below the actinopharynx, and the large retractor muscles projected from the gap thus torn in the body-wall.

EDWARDSIA WILLEYANA, n. sp. (Plate 51. fig. 5.)

Scapus not divided into areas by longitudinal grooves corresponding to the insertions of the macromesenteries, but invested by a bright chestnut-brown epidermis marked by numerous, fine, transverse rugæ and studded with numerous, colourless, more or less elevated, rounded vesicles or papillæ arranged in numerous, irregular, longitudinal rows. No distinct physa, but the body tapers towards the posterior extremity and forms a blunt cone on which the epidermis is very thin and the papillæ more closely crowded together. The capitulum very short, its surface marked by eight deep grooves corresponding to the insertions of the macromesenteries, the areas between the grooves tumid and raised at the edge of the oral disc into eight more or less pointed, marginal tubercles alternating with the bases of the outer circlet of tentacles. Tentacles sixteen in number, arranged in two circlets of eight each ; the tentacles subulate, very extensile ; in a retracted specimen some are simply infolded over the oral disc, others are partially or wholly invaginated. Eight macromesenteries extending from the oral disc to the posterior extremity, their retractor muscles highly developed in the region of and below the actinopharynx, but tapering abruptly to form mere strands of muscular fibres posteriorly. Micromesenteries very minute, with well-developed parietal muscles but no retractors, eight in number, two in each sulculo-lateral, one in each lateral and sulco-lateral macromesenterial interspace. Actinopharynx short, sacculated, with a distinct sulcus and sulculus. No definite sphincter muscle.

Length of contracted specimen, 40 mm. ; greatest diameter, 6 mm.

Hab. Straits of Rakaiya, New Britain.

In this single specimen of *E. willeyana* seven macromesenteries extend to the aboral end, one of the eight being shorter than the others. The aboral end is perforated by seven distinct pores leading into the seven aboral intermesenterial spaces. These pores are not visible externally in the spirit-preserved specimen, but can easily be demonstrated in sections. The detailed account of the situation and structure of these pores must, however, be deferred to a future paper.

II. *The Order of Succession of the Tentacles and Micromesenteries in the Edwardsidæ.*

I have been able to study the positions of the mesenteries and the relations of the tentacles to the intermesenterial chambers in six species of *Edwardsia* with some degree of exactitude. In these species the number of tentacles varies from ten in *E. mammillata* to thirty-two in *E. carnea*. In every case the number of mesenteries is the same as the number of tentacles—in other words, each tentacle corresponds to an intermesenterial chamber.

Other observers have given more or less detailed accounts and figures of the relations of the tentacles to the mesenteries in various species of *Edwardsia*; and, comparing their work with my own, it seems that the mesenteries and tentacles are formed in a regular and, on the whole, consistent sequence, which I shall attempt to describe in the following pages. Unfortunately, very little is known of the development of the Edwardsiæ, and in no case has the order of appearance of the micromesenteries and tentacles been determined. The youngest larvæ described have the eight primary macromesenteries fully developed.

Probably the youngest larva that has been studied is the one described as no. iv. of the larvæ with eight mesenteries by E. van Beneden (3). This larva was not identified as an *Edwardsia*, but it has all the appearance of belonging to that genus. It was ovoid in shape, without tentacles or buccal cone, and had the eight characteristic "Edwardsian" mesenteries, each provided with a large and prominent reniform muscle-banner. Boveri (5) obtained larvæ of similar character; in the youngest stage they were spheroidal and apparently without tentacles, but one of them was reared in an aquarium for three months and at the end of that time was 1 cm. long and showed Edwardsian characters, agreeing in colour and form with *E. claparedii*, but had only eight tentacles.

Meyer and Möbius (17) in 1863 obtained many specimens of *E. duodecimcirrata* (= *E. lütkeni*) with from eight to eleven tentacles, but only figure one with nine tentacles. From this figure it appears that the insertions of the mesenteries on the peristomial disc were marked by radiating lines of colour, as is usual in Edwardsiæ, and it is evident that the eight Edwardsian mesenteries are present and that an additional mesentery has been formed, probably in one of the lateral chambers. A single tentacle corresponds to each mesenterial chamber. With these may be compared the parasitic larva of *Halcampa chrysanthellum*, fully described and carefully figured by Haddon (13). This larva has six pairs of Hexactinian mesenteries, but only eight tentacles, and it is noteworthy that, with the exception of the two corresponding to the directive endocœles, all the tentacles are exocœlic; no tentacles are as yet formed in the dorso-lateral and ventro-lateral endocœles.

Putting this information together, it is evident that in the larval *Edwardsia* and also in the larval *Halcampa* the first tentacles to appear—which I shall henceforth call the primary tentacles—are formed as prolongations of the eight primary chambers into which the cœlenteron is divided by the eight so-called Edwardsian mesenteries. For convenience of description, these eight chambers may be called megacœles. It should be noted that in Hexactinians two of these tentacles—namely, those of the directive megacœles—become endocœlic, six become exocœlic, and, as Faurot (10) has shown in the case of *Ilyanthus parthenopæus*, these six are

the only exocœlic tentacles until three cycles of endocœlic tentacles are completed, when fresh tentacles are formed in the remaining exocœles, making, with the six primary tentacles, the full complement of twenty-four.

The next step is shown by my specimen of *E. mammillata*. This specimen is probably adolescent, and the secondary tentacles are just beginning to be formed. Here, as is shown in text-fig. 1, a micromesentery has been formed in each lateral megacœle. These micromesenteries correspond in position with the fifth couple formed in Hexactinian development, and might be considered homologous with them; but in none of the specimens I have examined do they bear any trace of longitudinal muscle-banners, and, as I shall show in the sequel, there is no evidence to warrant our attempting to make an exact homology between the micromesenteries of Edwardsidæ and the last two couples of the first cycle and the succeeding pairs of mesenteries in Hexactiniæ. As regards the tentacles in *E. mammillata*, it is obvious from text-fig. 1 that the two directives, and the tentacles on each side of them, are primary tentacles and prolong the two directive and the two dorso-lateral and ventro-lateral megacœlic chambers. In each lateral chamber there are two tentacles separated by the micromesentery. I was not able to determine the point with certainty, but, so far as I could judge, the more dorsal of the two tentacles in each of these chambers was the smaller and situated nearer the edge of the disc than the rest. If this be indeed the case, the ventral tentacle in each chamber is the primary, the more dorsal a newly-formed secondary tentacle. As a rule, the primary tentacle is dorsal, the secondary tentacle ventral in the lateral chambers; but in this matter *E. mammillata* agrees with *E. claparedii*.

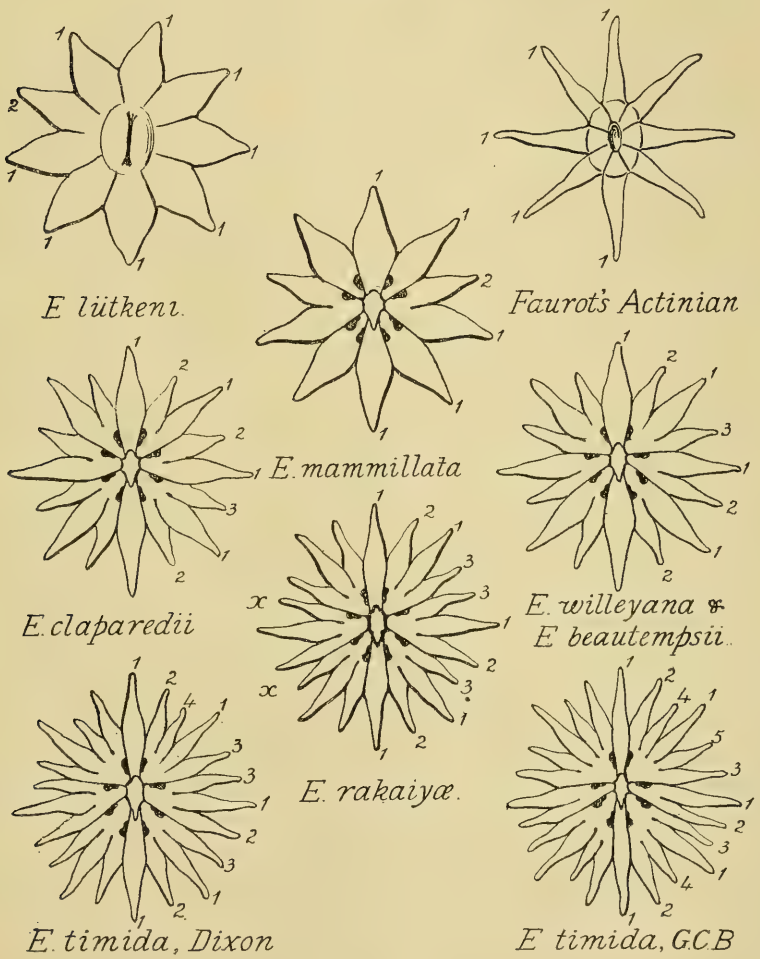
Specimens of species of *Edwardsia* with 11–15 tentacles have been mentioned by various authors, but none of them has been studied in detail. Therefore, we must pass on to forms with sixteen tentacles, of which four species are known—*E. claparedii*, *E. beautempsii*, *E. willeyana*, and *E. adenensis*. The first of these differs in some respects from the next two, and, as I shall show, *E. adenensis* is evidently an adolescent form of a species which has a larger number of tentacles when adult. *E. claparedii* has been thoroughly described by Andres (1). Of the sixteen tentacles, two are directives, two belong to each dorso-lateral megacœle, two to each lateral megacœle, and three to each ventro-lateral megacœle (text-fig. 1). They are alternately long and short, and Andres' figure shows clearly that the more ventral tentacle in the dorso-lateral and lateral megacœles is the primary, but the middle tentacle of the group of three in the ventro-lateral megacœle is the primary. Andres's figure also shows the eight micromesenteries, but he failed to realize their character and makes no mention of them.

E. beautempsii, described in detail by Faurot (10), and *E. willeyana* have the same number and arrangement of micromesenteries and tentacles, but differ from *E. claparedii* in the following respect: there are three tentacles in each of the dorso-lateral megacœles, the middle one of the group of three being the largest and obviously the primary tentacle. There are two tentacles in each of the lateral and ventro-lateral megacœles, and in each case the larger and more centrally placed primary tentacle is on the ventral side of the chamber, not on the dorsal as in *E. claparedii*. Evidently the precise order of the appearance of the micromesenteries and tentacles in the megacœles is liable to some variation within the limits of the genus; and it is just this variation that negatives any attempt to homologize the micromesenteries that first arise in the lateral and ventro-lateral megacœles of the Edwardsiæ with the fifth and sixth couples of the first cycle of Hexactinian mesenteries. Were the order of appearance always the same as it is in *E. claparedii* (and possibly in *E. mammillata*) the homology would be justified; for in this species the primary tentacle remains in what in a Hexactinian would be an exocœle, and the new secondary tentacle is formed in what in a Hexactinian would be an endocœle, and thus far the order of succession would be exactly analogous to what has been recorded by Faurot (10) for *Ilyanthus parthenopæus* and by Haddon (13) for *Halcampa chrysanthellum*. But the different order of succession in *E. willeyana* forbids our extending this homology to the whole genus. In this species (and also in *E. timida*, as I shall show further on), in both the lateral and ventro-lateral megacœles, the primary tentacle remains in what in a Hexactinian would be the endocœle, and the newly-formed secondary tentacle is in the exocœle. Further, when new micromesenteries and tentacles are added, as is the case in *E. timida*, they arrive on the *dorsal* side of the primary tentacles (text-fig. 1), and therefore in what in a Hexactinian would be the endocœles. Thus a fundamental rule of the succession of mesenteries in Hexactinians would be violated. The conclusion is that the mesenteries in question in the Edwardsiæ are not homologous with, and certainly not homogeneous in the sense of being derived by descent from, the fifth and sixth couples of the first cycle of Hexactinian mesenteries.

In *E. rakaiyæ* there are twenty mesenteries (eight macromesenteries and twelve micromesenteries) and twenty tentacles, disposed in a very regular manner, as is shown in text-fig. 1. In this species it is sufficiently obvious that the eight larger primary tentacles form the inner cycle, and that it is the primary tentacle that occupies the central position in the group of three occupying each of the dorso-lateral, lateral, and ventro-lateral megacœles. It follows from this arrangement that the tentacles do not alternate as in *E. claparedii* and *E. willeyana*, but that there are four pairs of contiguous outer cycle tentacles—one member of each pair on either side of the dorso-lateral and ventro-lateral macromesenteries. In this species there is no

evidence available to show whether the secondary tentacles appear on the dorsal or ventral side of the primary tentacles in the lateral and ventro-lateral megacœles. I am inclined to the opinion that they appear, as in *E. willeyana*, on the ventral side, but chiefly because, if they do, the case of *E. adenensis* meets with a ready explanation. For if, after sixteen tentacles

Text-figure 1.



have been established in this species, tertiary mesenteries arise forming the microcœles marked *x*, *x* in text-fig. 1, but the tentacles corresponding to these microcœles are retarded in development, we get precisely the condition described by Faurot for *E. adenensis*, a species which has hitherto been regarded as an exception, because it has a greater number of mesenteries

than tentacles. I think there can be no doubt that Faurot's specimen had not attained its full growth and full complement of tentacles. In the two living specimens of *E. timida* kept under careful observation by G. Y. Dixon (6) there were respectively 20 and 22 tentacles. In both specimens of this species that I studied by means of sections there were twenty-four tentacles and twenty-four mesenteries. Dixon's specimen with twenty tentacles, referred to by him as $\beta\beta$, was abnormal ; but his specimen with twenty-two tentacles exhibits an arrangement perfectly consistent with what I have observed. In Dixon's $\alpha\alpha$ specimen the arrangement of the tentacles is the same as in *E. rakaiæ*, but a quaternary tentacle has made its appearance on the dorsal side of the primary tentacle in each of the dorso-lateral megacœles. At least, this is what I surmise has taken place, because in both my specimens of *E. timida* the largest number of tentacles and mesenteries is in this megacœle—so I have taken the liberty to reverse Dixon's figure. He only studied the living animal, and could not tell, except by sections, which was the dorsal and which the ventral aspect of the animal.

In my two specimens of *E. timida* the tentacles are twenty-four in number, and there are the usual eight macromesenteries and sixteen micromesenteries. As studied in sections, the tentacles are obviously of different lengths, and, though the relative lengths are not always a safe guide to the age of tentacles in Actinians, I do not think I am wrong in assuming that the conspicuously longer and larger tentacles in these specimens were formed earlier than the shorter and smaller, especially as both specimens give the same results in this respect. Each of the directive megacœles is prolonged, as usual, into a single primary tentacle. The dorso-lateral megacœle gives off five tentacles, of which the two outermost, respectively nearest the dorsal and dorso-lateral macromesenteries, are conspicuously longer than the others. Within them are two very short tentacles and in the centre a long tentacle, which is clearly the primary. The probable order of appearance of these tentacles is indicated by the numerals in text-fig. 1. In each lateral megacœle there is only a single micromesentery separating two unequally-sized tentacles. Of the latter the dorsal is decidedly the longer, and must be identified with the primary tentacle. My specimens have therefore a smaller number of mesenteries and tentacles in the lateral megacœles than Dixon's, though more advanced in other respects. In the ventro-lateral megacœles there are three mesenteries dividing the peripheral part of the megacœle into four microcœlic chambers, from each of which issues a single tentacle. That nearest the ventral directive is large ; the next one to it is small ; then follows a large tentacle ; then a small one, next to the ventro-lateral macromesentery. In this chamber it is obvious that a quaternary tentacle has been formed on the ventral side of the primary.

Since writing the above, I have had the opportunity of studying a single example of *Edwardsia beautempsii*, de Q., and five examples of *E. carnea*, Gosse, sent to me from Plymouth by the Director of the Marine Biological Station. I kept these animals alive in an aquarium for some time, in the hope that I might obtain larvæ; but, failing to observe any signs of reproduction, I killed and made sections of them. As regards *E. beautempsii*, I have nothing to add to Faurot's account of the anatomy. The five examples of *E. carnea* were often ensconced in holes bored by *Saxicava* in a small piece of limestone. It was impossible to extract them from their holes without injury; so all five had to be killed at one operation, and only three were sufficiently well preserved in an expanded condition to admit of microscopical examination. I will refer to these three as specimens A, B, and C.

A had 24 tentacles—one in each of the dorsal and ventral directive megacœles, three in the dorso-lateral, three in the ventro-lateral, and four in the lateral chambers on each side of the body.

In specimen B there were thirty tentacles, disposed as follows:—One in each of the dorsal and ventral directive megacœles; four in each of the lateral and ventro-lateral megacœles; on the right side of the body (left in the drawing) five in the dorso-lateral megacœle, and seven in the corresponding megacœle on the left side of the body. In this specimen, therefore, growth had proceeded more rapidly in the left dorso-lateral megacœle than in the right.

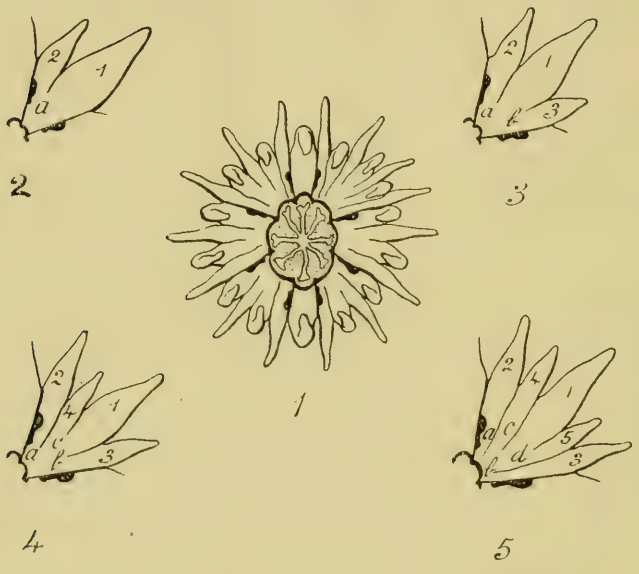
In specimen C there were thirty-two tentacles: five in each dorso-lateral megacœle, six in each lateral megacœle, four in each ventro-lateral megacœle, and the two dorsal and ventral directive tentacles.

It is a good example of the irregularity of growth in Edwardsias that in A and C the largest number of tentacles and mesenteries is in the lateral megacœles, but in B in the dorso-lateral megacœles. In the living animals, when fully expanded, no appreciable difference in the length of the tentacles could be detected; but in all the five specimens, when expanded and in repose, every alternate tentacle was held straight out in radial fashion and the intervening tentacles were curled inwards towards the oral disc. So far as I could determine, the dorsal and ventral tentacles were always curled inwards.

It was impossible to judge of the age of the tentacles by their lengths in *E. carnea*; but in specimen B, which was killed in a fully expanded condition, I was able to observe that the micromesenteries were of different lengths, and as the number of tentacles and micromesenteries in the dorso-lateral megacœles of this specimen was different, it afforded an excellent opportunity of forming a judgment as to the order in which the micromesenteries and tentacles were developed. Text-fig. 2, which is founded on a combination of a series of transverse sections, shows that in the right

(left in the figure) dorso-lateral megacœle the two micromesenteries adjacent to macromesenteries extend nearly across the peristome to the actinopharynx, the two micromesenteries in the middle of the chamber are shorter, but that on the dorsal side is markedly the shorter of the two. In the corresponding megacœle on the left side of the body (right in the figure) there are six micromesenteries, of which the two adjacent to the macromesenteries are the longest, the two in the middle of the chamber are very short, and the two others are of intermediate length. In each of the lateral and ventro-lateral

Text-figure 2.



1. Oral disc of a specimen of *Edwardsia carnea*, Gosse, with 30 tentacles, eight macromesenteries, and twenty-two micromesenteries.

2–5. Diagrams of one of the dorso-lateral megacœles, showing the probable order of development of the micromesenteries and tentacles. *a–d*, micromesenteries lettered according to their probable order of development; *1–5*, tentacles.

megacœles there are three micromesenteries, of which the two adjacent to the macromesenteries are the longest, the middle one being distinctly shorter.

It can hardly be doubted that the longer micromesenteries are the older, the shorter the more recently formed. This rule holds good for all other Actinians, and there are no grounds for supposing that the Edwardsiæ form an exception to it. On the assumption that the rule is applicable to this case, my interpretation of the facts is given in the series of diagrams of a single megacœle (text-fig. 2, 2 to 5).

In 2 the megacœle has been divided peripherally into two microcœles by the formation of the micromesentery *a*. The primary tentacle of the original undivided megacœle is marked *1*, and the new tentacle *2* has grown out from the more dorsal microcœle. In 3 the megacœle has been subdivided into three microcœles by the formation of the micromesentery *b* ; the primary tentacle remains in the middle, and the new tentacle *3* has sprouted from the ventral microcœle. This is the condition found in all the dorso-lateral, lateral, and ventro-lateral megacœles in *E. rakaiyæ*.

In 4 a new micromesentery *c* has been formed on the dorsal side of the primary tentacle, and in connection with it the new tentacle *4* has been formed. In the next stage (text-fig. 2, 5) a new micromesentery *d* has been formed on the ventral side of the primary tentacle, and the new tentacle *5* has been formed in connection with it. This is the condition of the right dorso-lateral megacœle of specimen B and of both dorso-lateral megacœles of specimen C. The formation of two new micromesenteries, with their corresponding tentacles, one on the dorsal side and one on the ventral side of the primary tentacles, will produce the arrangement found in the left dorso-lateral megacœle of specimen B.

My examples A and C of *E. carnea* were not so fully expanded as example B, and their peristomes being crumpled it was not possible to determine the lengths of the micromesenteries with the same accuracy in sections ; but, so far as I was able to observe, they showed the same arrangement as has been described above.

In the ventro-lateral megacœles the order of appearance of the micromesenteries and tentacles is the reverse of that described for the dorso-lateral megacœles, and in the lateral chambers it appears that the first micromesentery may appear on the dorsal side of the primary tentacle, as in *E. claparedii*, or on the ventral side, as in *E. willeyana* and *beautempsii*.

It will be observed that the inferences drawn from the study of the length of the micromesenteries in a single species confirm in every respect the inferences drawn from the relative lengths and insertions of the tentacles in a number of other species of the genus *Edwardsia*.

Summing up the preceding argument, the law of the succession of the mesenteries and tentacles in the Edwardsiæ may be stated as follows :—

After the establishment of eight macromesenteries dividing the cœlenteron into eight megacœles, each of the latter is produced in the peristomial region into a single primary tentacle.

The two directive megacœles are never subdivided, and never prolonged into more than one tentacle.

In the capitulum the peripheral portions of the remaining megacœles are subdivided into microcœles by the successive formation of micromesenteries.

The micromesenteries appear singly, and usually in the following order on each side of the actinopharynx. First, a single micromesentery in the lateral megacœle ; then a single micromesentery successively in the dorso-lateral and the ventro-lateral megacœle. In some cases, however (*E. claparedii*), the micromesentery of the ventro-lateral megacœle is formed before that of the dorso-lateral.

Usually in the lateral and ventro-lateral megacœles the more dorsal of the two microcœles formed by the first micromesentery bears the primary tentacle, the more ventral the secondary tentacle ; but the opposite is the case in *E. claparedii* and probably in *E. mammillata*. In the dorso-lateral megacœle the primary tentacle is always in the ventral of the first two microcœles, the secondary tentacle in the dorsal.

Succeeding micromesenteries are formed singly and always on the side of the primary tentacle furthest from the last-formed secondary tentacle. As the microcœles and the tentacles into which they are prolonged are always formed first on one side, then on the other side of the primary tentacle, the latter always occupies a central or subcentral position in the megacœle.

The rate of growth is usually greatest in the dorso-lateral, next greatest in the ventro-lateral, and least in the lateral megacœle ; but in *E. claparedii* the rate of growth in the ventro-lateral megacœle seems to outstrip that in the dorso-lateral, and in some examples of *E. carnea* growth is most rapid in the lateral megacœles.

It is clear that, after the stage with eight mesenteries is reached, the sequence of mesenterial development in the Edwardsiæ differs altogether from that of the Hexactinians, and, indeed, from that of any known Actinian. The characteristic feature is that any two micromesenteries of the same age in any given megacœle constitute a *couple*—that is to say, they arise as singles on opposite sides of the actinopharynx, and not in *pairs* in the exocœles as in Hexactinians and Zoanthids. *Edwardsia* therefore retains the bilateral mode of growth throughout its existence, and exhibits no trace of the biradiality characteristic of the second stage of growth of the Hexactinians. In this respect it shows some analogy with the Cerianthidæ, but differs altogether from the latter in the fact that both the ventral and dorsal directive megacœles remain undivided throughout life, and increase of growth takes place on either side of the two directive chambers, and not in one of them. On the other hand, the persistence of the two directive chambers in an undivided state is a feature which the Edwardsiæ share in common with the Hexactiniæ and the Zoantheæ, and points to a fairly close alliance between the three groups. There is, further, some analogy in the mode of growth of Edwardsiæ and Zoantheæ, in that in both the addition of mesenteries after a certain stage proceeds more rapidly in certain megacœles ; but the Zoantheæ are

much more specialised in this respect than the Edwardsiæ. The outstanding feature, however, in the growth of the Edwardsiæ is that, after the eight-rayed stage is reached, the mesenteries continue to be formed in *couples of singles* and not in *couples of pairs*, as in the Dodecactiniaria and Zoanthinaria. In short, the mode of development characteristic of the first four couples formed in the larvæ of Zoantheæ, Actinians, and Madreporaria is continued to the end in Edwardsidæ. This mode of development is universally regarded as primitive. The Edwardsidæ, then, retain the primitive mode of development and growth throughout their existence and for this reason must be regarded as a separate branch of a primitive stock in which only four couples * of mesenteries were present. From this stock the Edwardsiaria, the Zoanthinaria, and the Dodecactiniaria have been derived.

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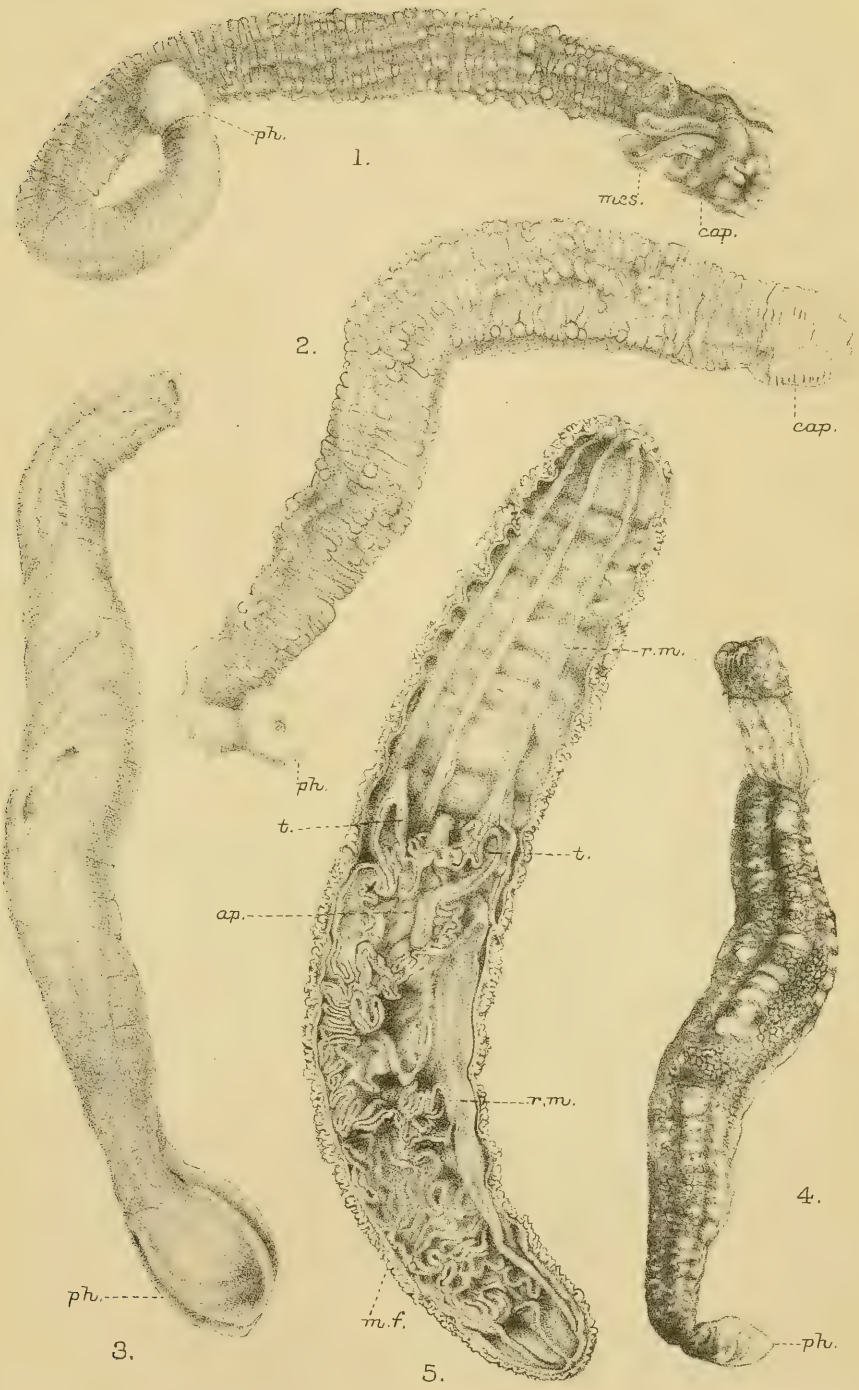
* Throughout this paper I have used the terms "couple" and "pair" in the sense indicated by Faurot. In my article on the Anthozoa in Lankester's 'Treatise on Zoology' I use the same terms, but in exactly the opposite sense to Faurot. My article, though published in 1900, was written in 1895, the same year in which Faurot's paper appeared. His use of the terms has priority over mine and should be adopted.

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EXPLANATION OF PLATE 51.

cap., capitulum ; *ph.*, physa ; *mes.*, mesenteries.

Fig. 1. *Edwardsia mammillata*, n. sp. The specimen has burst below the capitulum, and the mesenterial filaments are extruded.
2. *Edwardsia rugosa*, n. sp.
3. *Edwardsia vermiformis*, n. sp.
4. *Edwardsia rakaiyæ*, n. sp. The animal has burst owing to excessive contraction in spirit, and the inner wall of the introverted part of the scapus is exposed in the upper part of the figure.
5. *Edwardsia willeyana*, n. sp. The retracted animal has been cut in half longitudinally, and the figure shows the tentacles *t.*, *t.*, the actinopharynx *a.p.*, the longitudinal retractor muscles *r.m.*, and the mesenterial filaments *m.f.* Owing to excessive contraction in spirit, the capitulum has been torn away from the scapus and has been pulled down to the inside of the lower half of the body.



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NEW SPECIES OF EDWARDSIA.

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[Synonyms and native names are printed in *italics*. A star * denotes the first publication of a name.]

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